



Environnement  
Canada

Environment  
Canada

Canada

## Le système d'analyse Regional- 4D-Var

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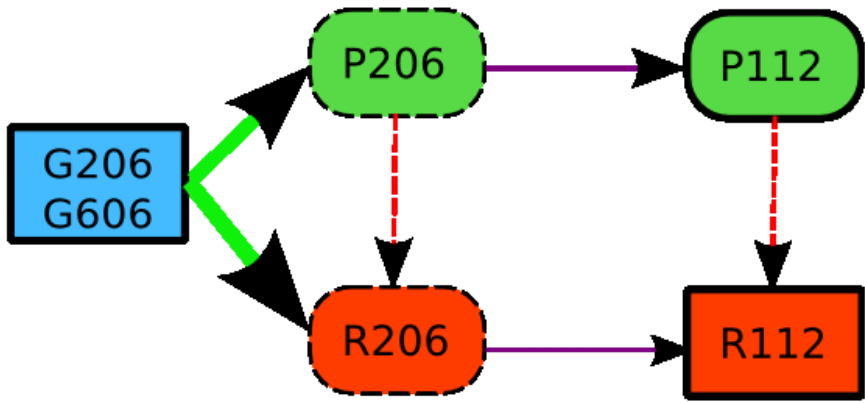
**Seminaire Interne Special**

**Salle des Vents, Dorval, Qc, Can**

**Jeudi 28 Avril 2011, 11h-12h.**

*1 Meteorological Research Division*

*2 Canadian Meteorological Center (Development)*



**G** : Global Model (33 km)  
**P** : Pilot Model (55 km)  
**R** : Regional Model (15 km)

Piloting  
 Trial field  
 Global analysis used

Trial field  
 3D-VAR FGAT Analysis  
 4D-VAR Analysis

# Configuration Strato-2B (elaav) (REG-3D)

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- Ajouts des nouvelles observations
  - Humidité des avions
  - 4 canaux AIRS assimilés de façon globale (precedemment rejetes pres des poles)
  - IASI du satellite METOP-2 (**62 channels, sensitive to temperature below 150hPa**)
  - SSMI/S (seulement les canaux semblables à SSM/I) (**7 SSMI-like channels**)
  - GeoRad (**3 new geostationary satellites, 1 water vapour channel**)
  - Thinning spatial de 150 km
- Analyse de température de la mer à 0.2 degrés
- Champs de surface du global (33 km) relaxés avec Liebman pour interpolation vers la grille du pilote (55 km)
- Thinning temporel 3D pour le LAM et son pilote

## Configuration (eI040) REG-4D

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- Mêmes types d'observations que Strato-2B
- Thinning temporel 4D pour le LAM (+80%)
  - Le pilote garde du thinning temporel 3D puisque c'est toujours un 3D-Var
- Filtre digital pour le champ d'essai LAM ainsi que la prévision (GEM-333 + Updates, Physique 472)
- Le TL-AD LAM est piloté par le champ d'essai pilote
- 25 itérations

# Description des expériences

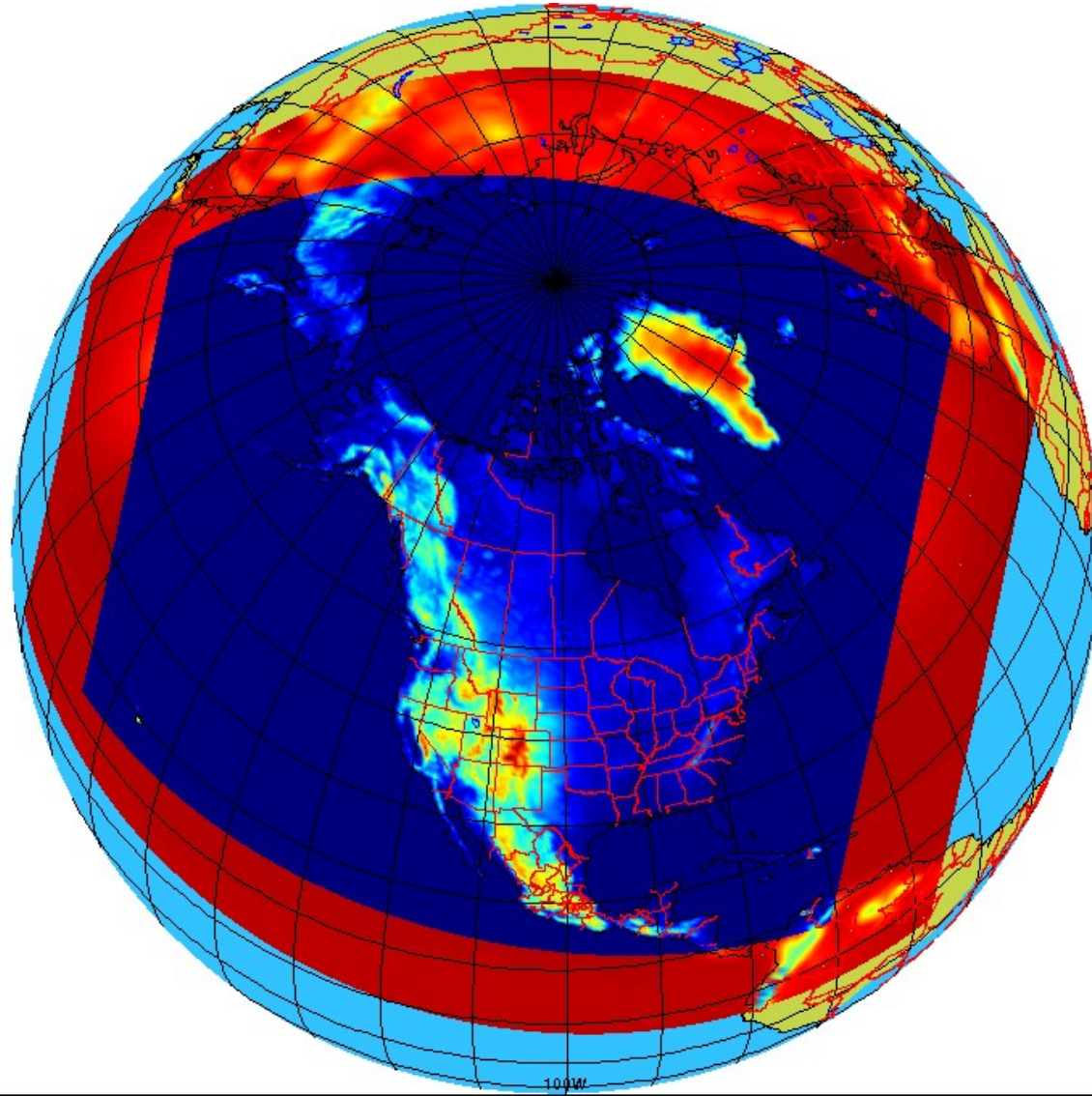
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- 118 cas d'hiver
  - du 2009010100 au 2009022812, toutes les 12 heures
  
- 118 cas d'été
  - du 2008070100 au 2008082812, toutes les 12 heures

Operational Regional System (REG-LAM3D) Oct. 20th 2010  
Fillion et al. 2010, 25, *Wea. Forecasting*, 1645-1669.

NL-High 15-km grid (649x672)

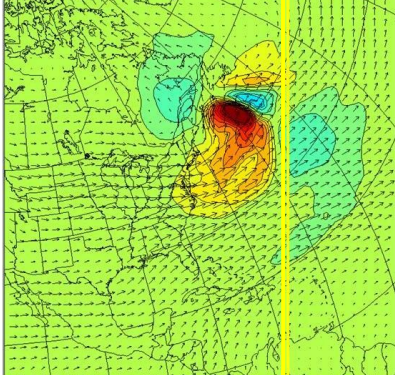
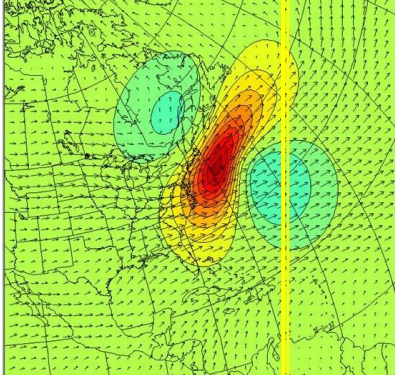
NL-Low/TL/AD 100-km grid (138x138)



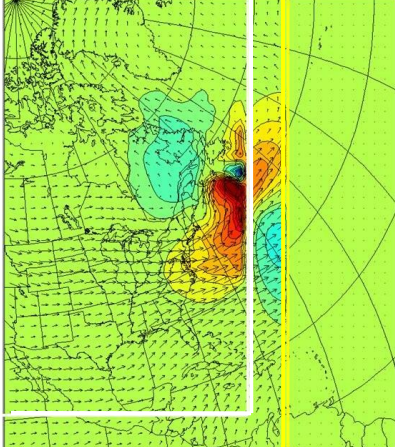
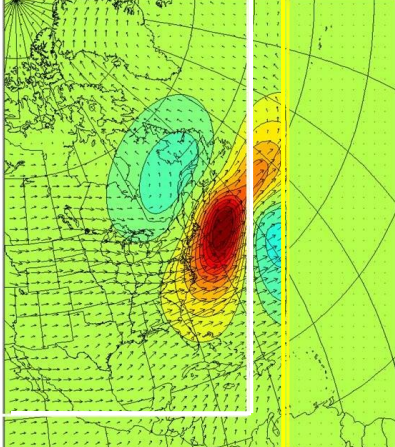
T= - 3 hr

T= 3 hr

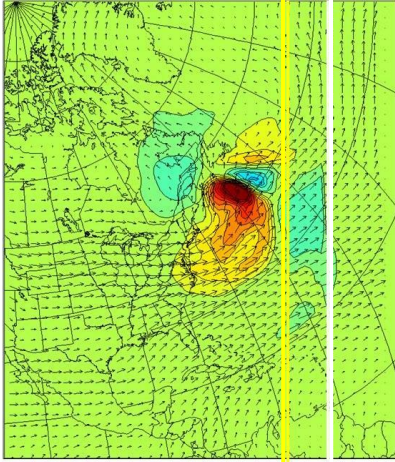
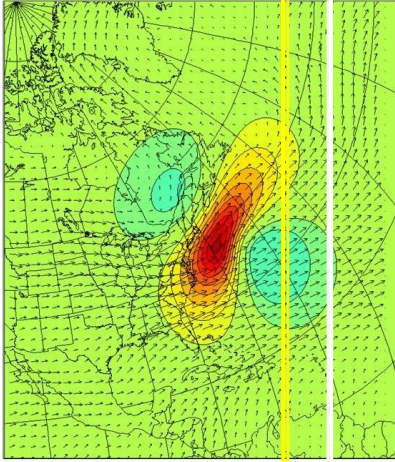
**REG-4D-GLB**  
100 km, 400x200



**REG-4D-LAM**  
100 km, 104x104

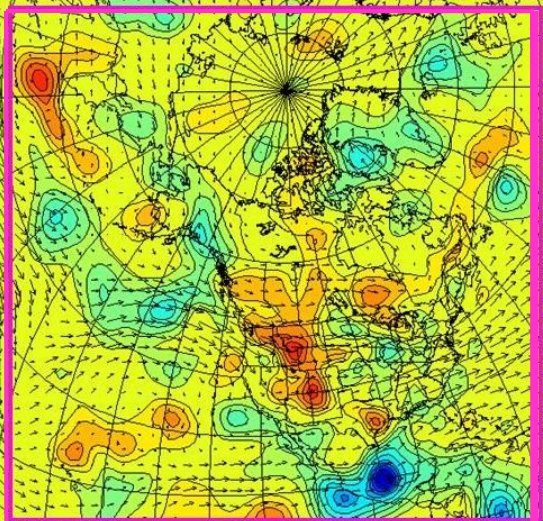


**REG-4D-LAM**  
100 km, 138x138



Cœur TL  
Frontière NL

T= - 3 hr

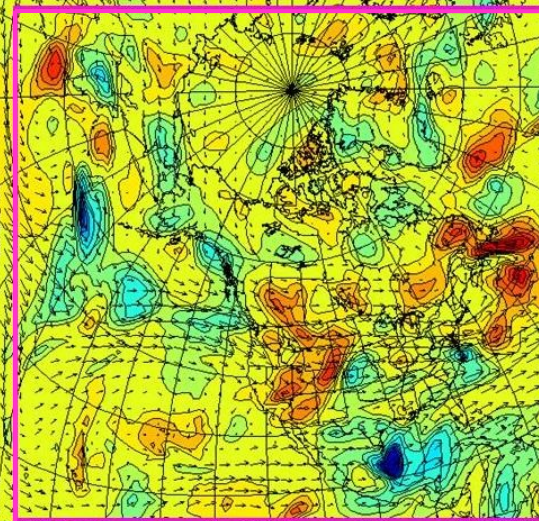


REG-4D-GLB  
100 km, 400x200

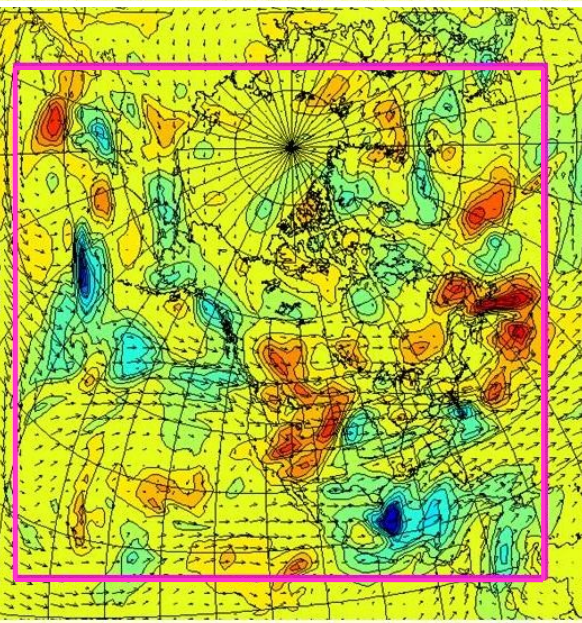
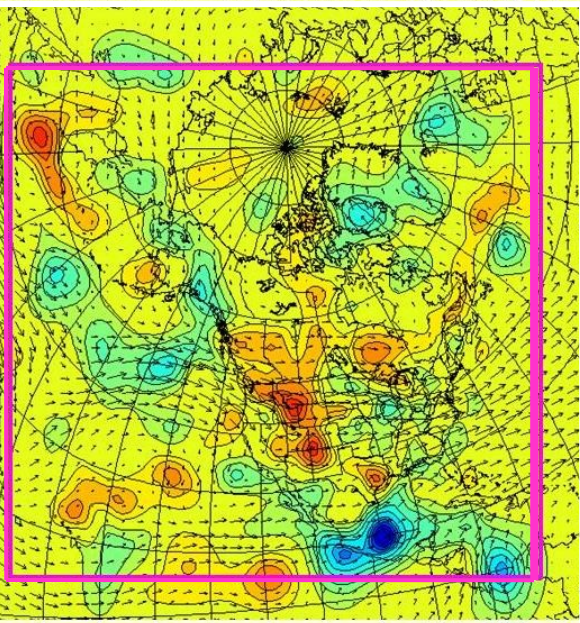
Cœur TL

Frontière NL

T= 3 hr



REG-4D-LAM  
100 km, 138x138

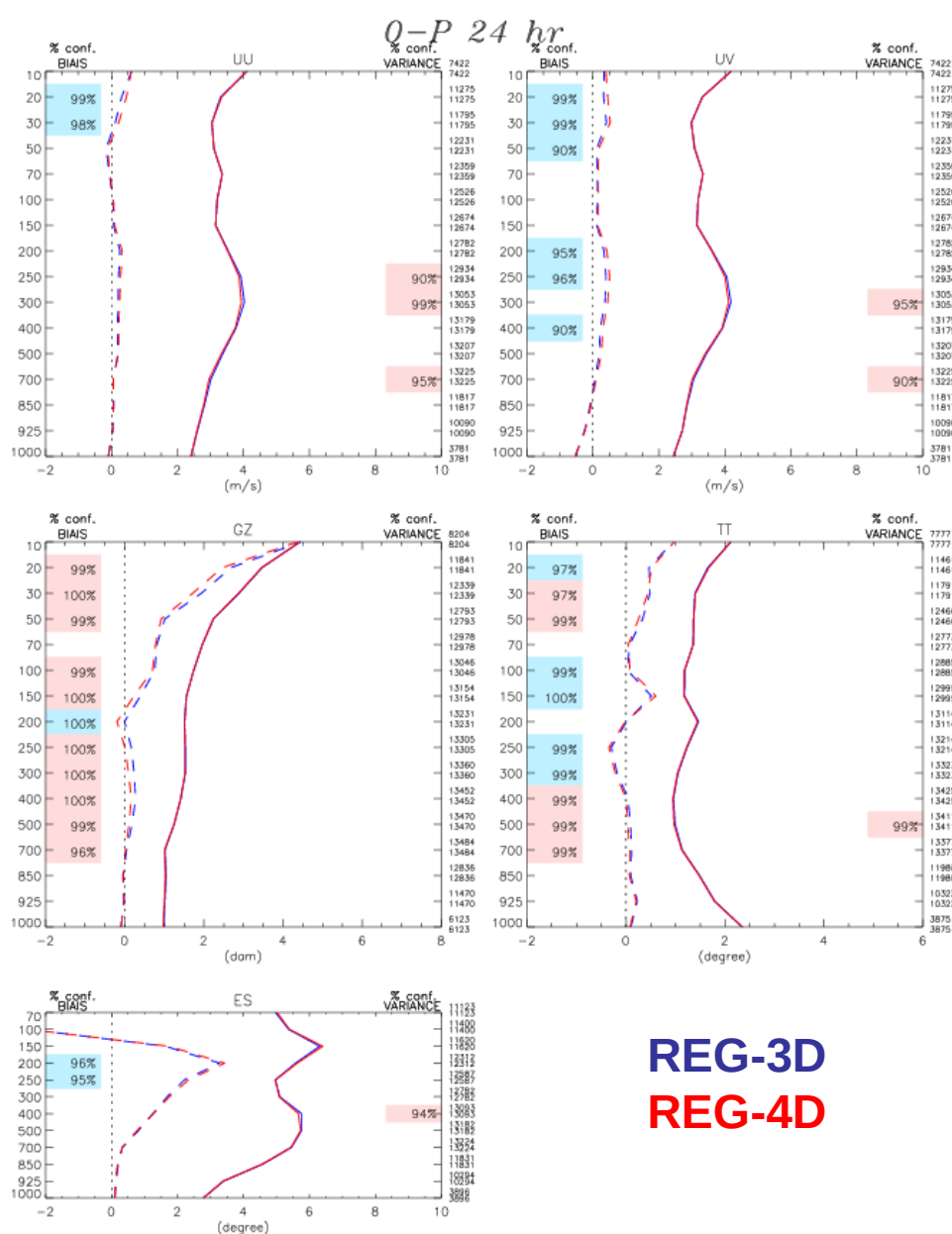




Winter 2009 (118 cases)

24-h

NA+



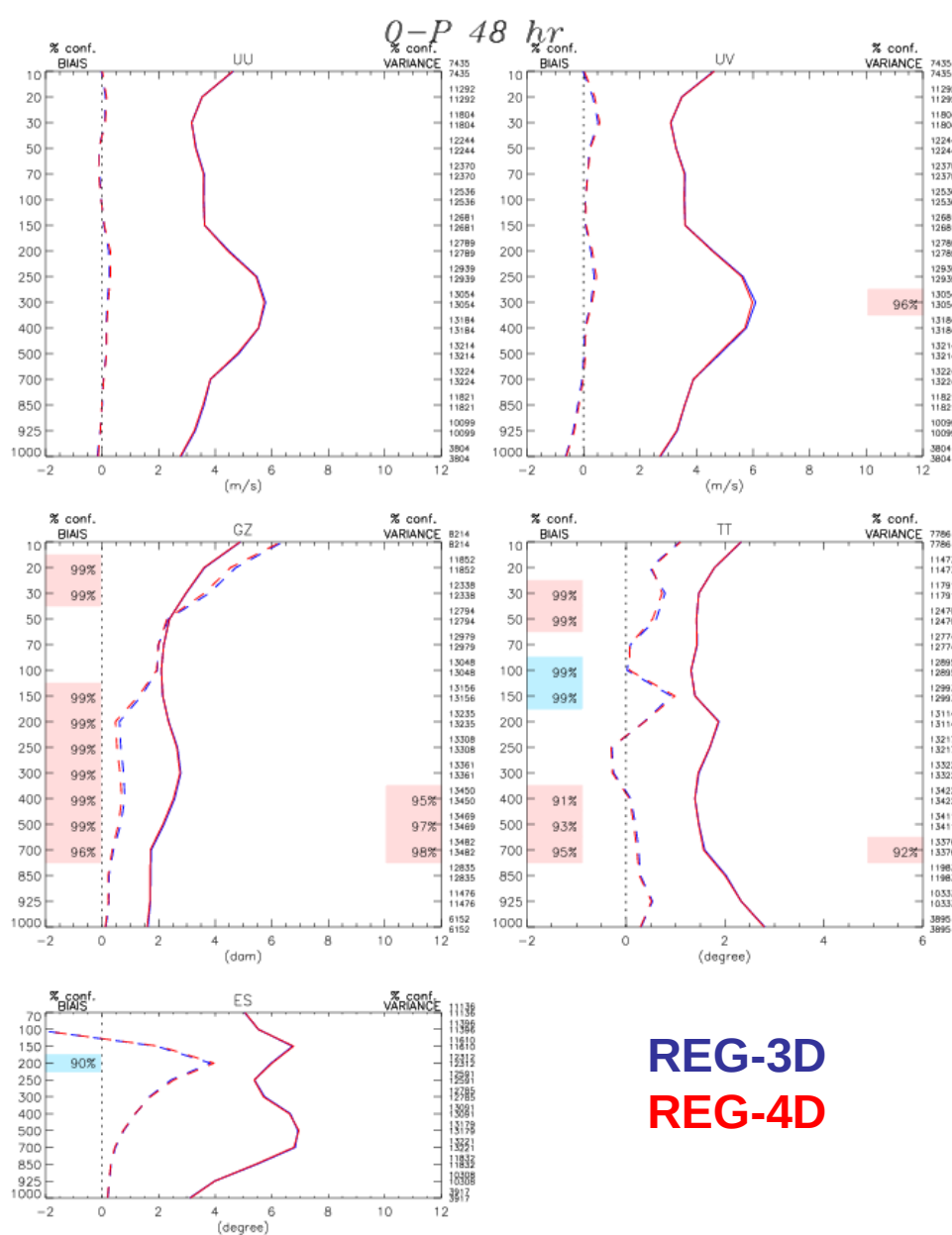
**REG-3D**  
**REG-4D**

◇	—	E-T m_uu_048_regelaavh09 ( 118 )
◇	- - -	BIAS m_uu_048_regelaavh09
◇	—	E-T m_uv_048_regel040h09 ( 118 )
◇	- - -	BIAS m_uv_048_regel040h09

Type : O-P 24 hr  
 Region : Amerique du Nord plus  
 Lat-lon: ( 25N, 170W ) ( 85N, 40W )  
 Stat. communes

# Winter 2009 (118 cases) 48-h

NA+



**REG-3D**  
**REG-4D**

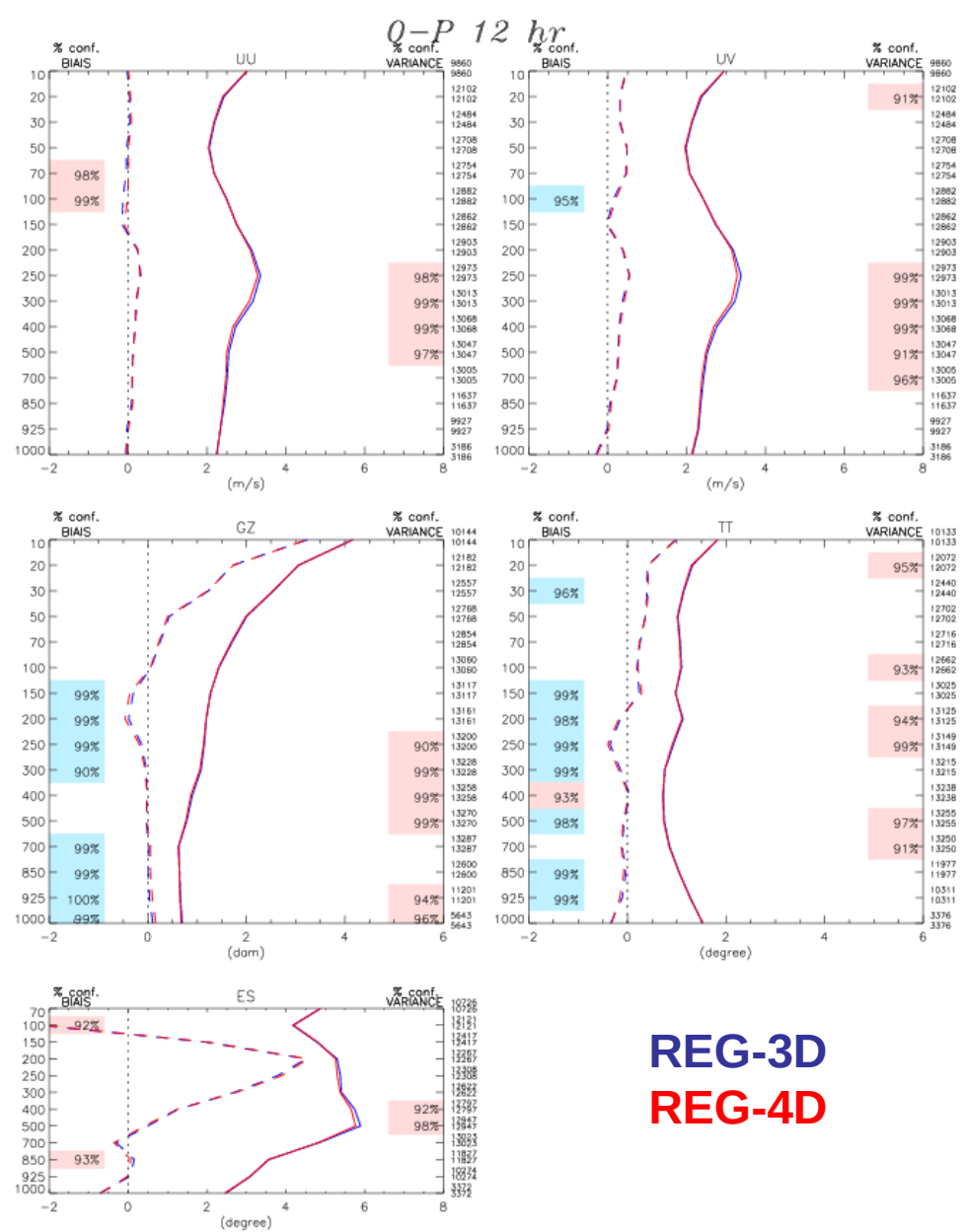
◇	—	E-T m_uo_048_regelaavh09 ( 118 )
◇	- - -	BIAIS m_uo_048_regelaavh09
◇	—	E-T m_uo_048_regel040h09 ( 118 )
◇	- - -	BIAIS m_uo_048_regel040h09

Type : O-P 48 hr  
 Region : Amerique du Nord plus  
 Lat-lon : ( 25N, 170W ) ( 85N, 40W )  
 Stat. communes

Summer 2008 (118 cases)

12-hr

NA+



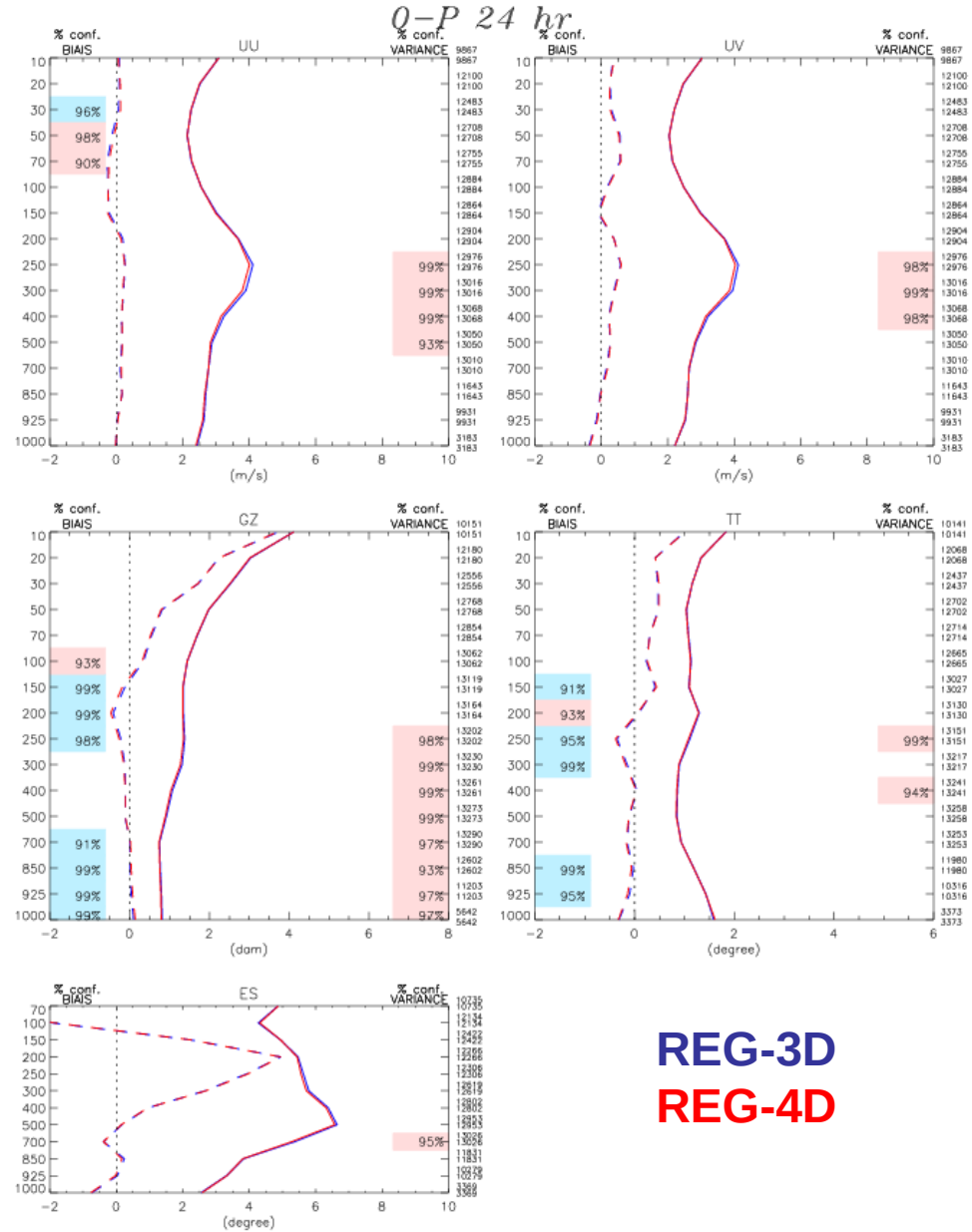
**REG-3D**  
**REG-4D**

◇	—	E-T m_uo_04B_regelaave08 ( 118 )
◇	- - -	BIAS m_uo_04B_regelaave08
◇	—	E-T m_uo_04B_regel040e08 ( 118 )
◇	- - -	BIAS m_uo_04B_regel040e08

Type : O-P 12 hr  
 Region : Amerique du Nord plus  
 Lat-lon : ( 25N, 170W ) ( 85N, 40W )  
 Stat. communes

# Summer 2008 (118 cases) 24-hr

NA+



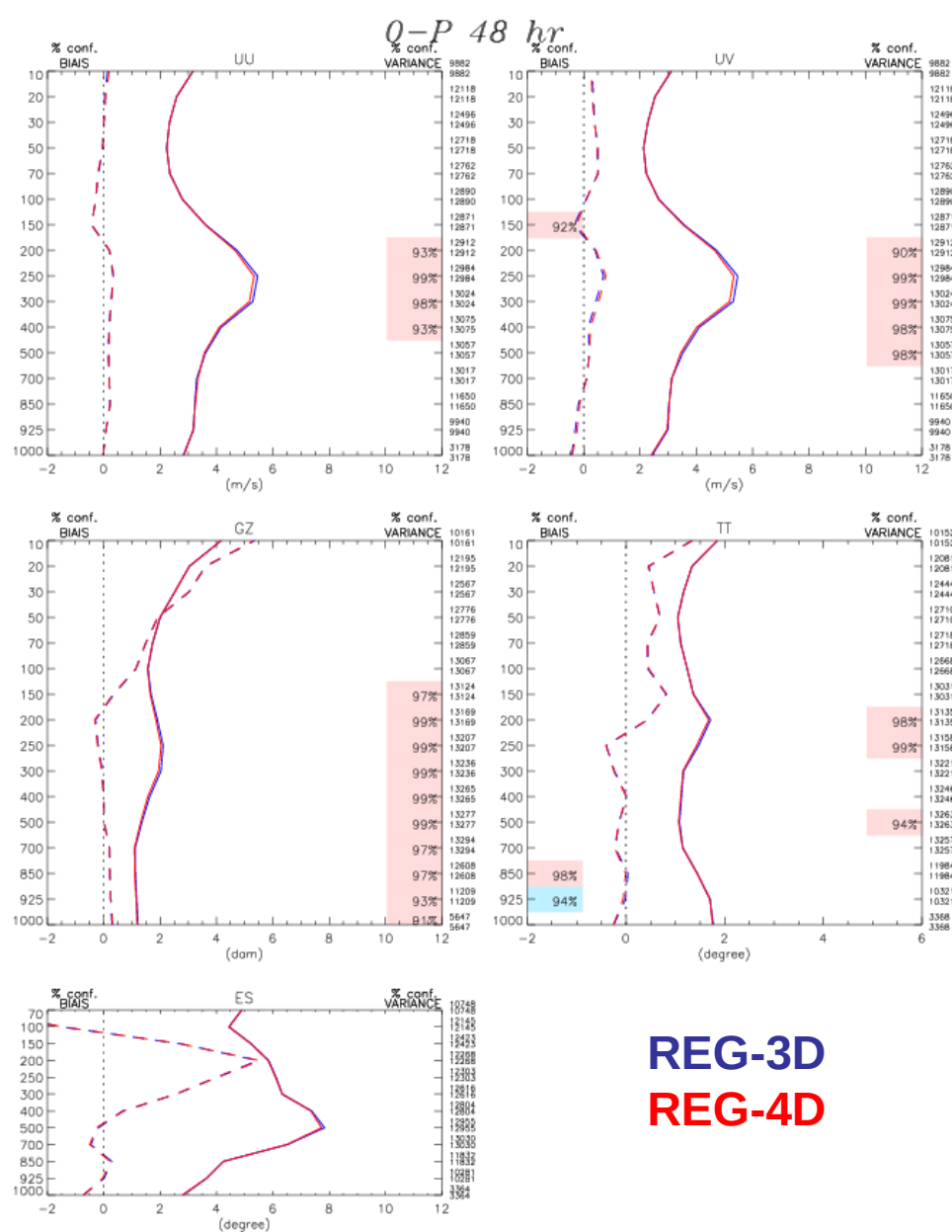
**REG-3D**  
**REG-4D**

◇	—	E-T m_uu_04B_regelaave08 ( 118 )
◇	- - -	BIAIS m_uu_04B_regelaave08
◇	—	E-T m_uu_04B_regel040e08 ( 118 )
◇	- - -	BIAIS m_uu_04B_regel040e08

Type : O-P 24 hr  
 Region : Amerique du Nord plus  
 Lat-lon : ( 25N, 170W ) ( 85N, 40W )  
 Stat. communes

# Summer 2008 (118 cases) 48-hr

NA+



**REG-3D**  
**REG-4D**

◇	—	E-T m_uo_048_regelaave08 ( 118 )
◇	- - -	BIAS m_uo_048_regelaave08
◇	—	E-T m_uo_048_regel040e08 ( 118 )
◇	- - -	BIAS m_uo_048_regel040e08

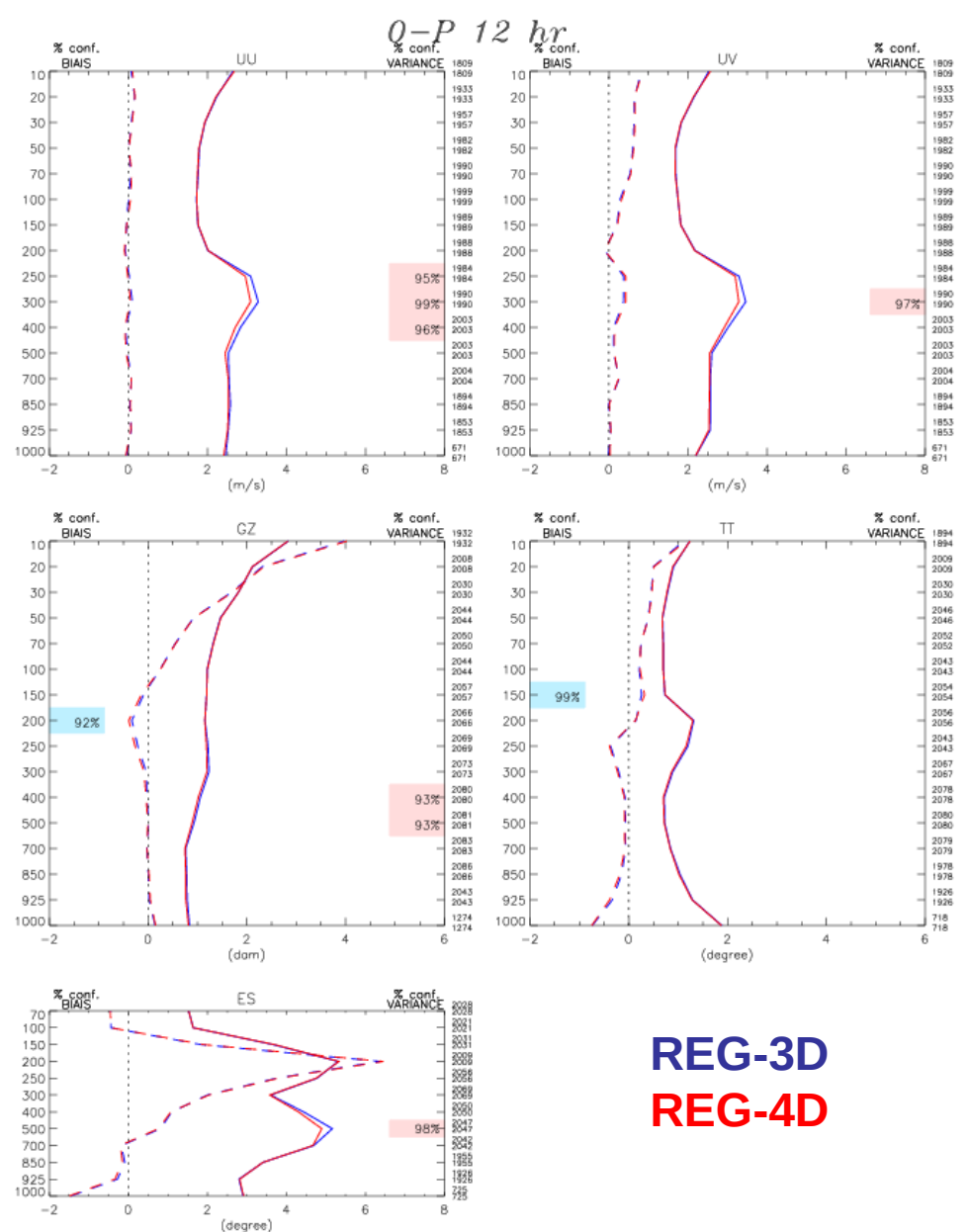
Type : O-P 48 hr  
 Region : Amerique du Nord plus  
 Lat-lon: ( 25N, 170W ) ( 85N, 40W )  
 Stat. communes

# PROPOSED METEOROLOGICAL MONITORING INFRASTRUCTURE (MET/NAV AREAS)



# Summer 2008 (118 cases) 12-h

## Arctic



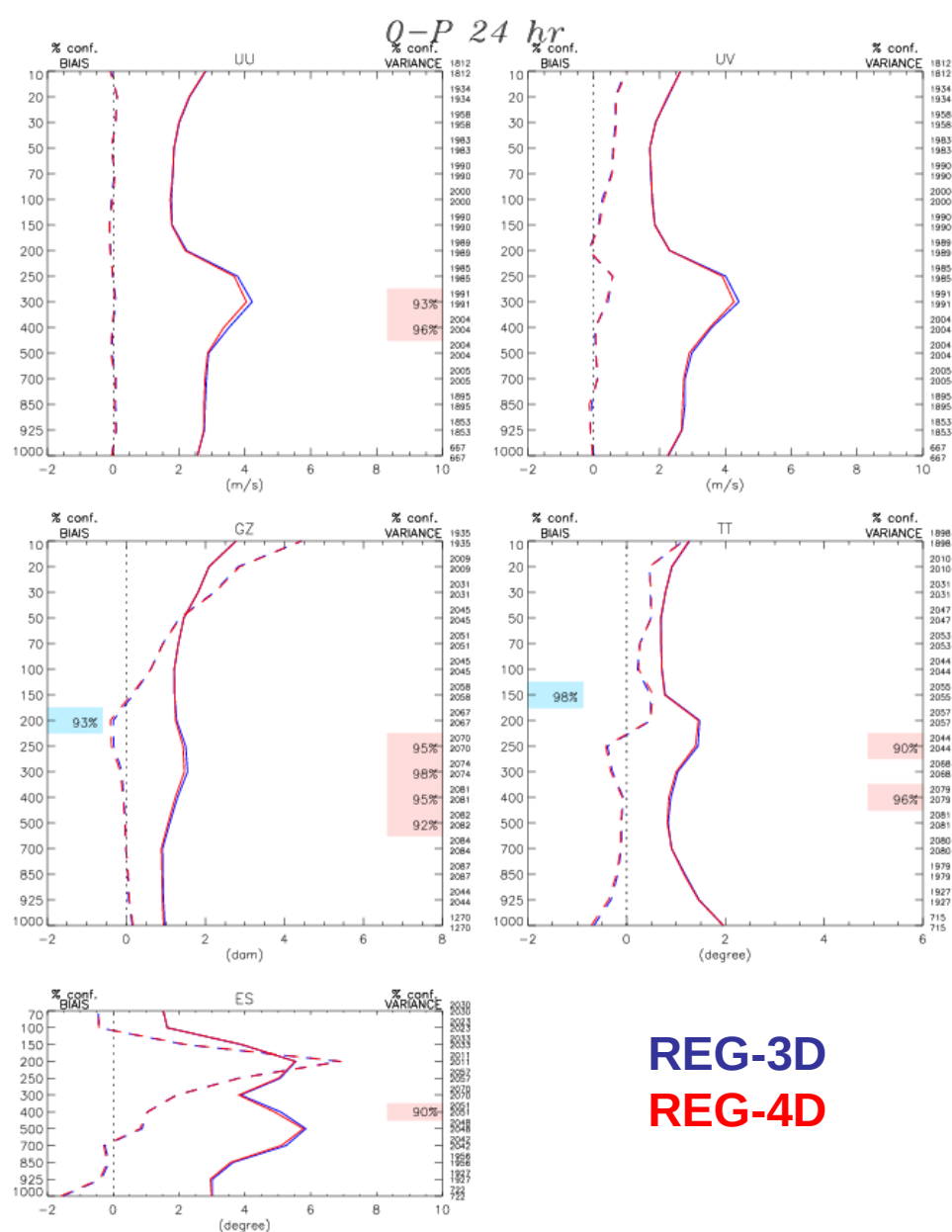
**REG-3D**  
**REG-4D**

◇	—	E-T m_uu_04B_regelaave08 ( 118 )
◇	- - -	BIAS m_uu_04B_regelaave08
◇	—	E-T m_uv_04B_regel040e08 ( 118 )
◇	- - -	BIAS m_uv_04B_regel040e08

Type : 0-P 12 hr  
 Region : Arctique canadien  
 Lat-lon : ( 58N, 141W ) ( 90N, 50W )  
 Stat. communes

# Summer 2008 (118 cases) 24-h

## Arctic



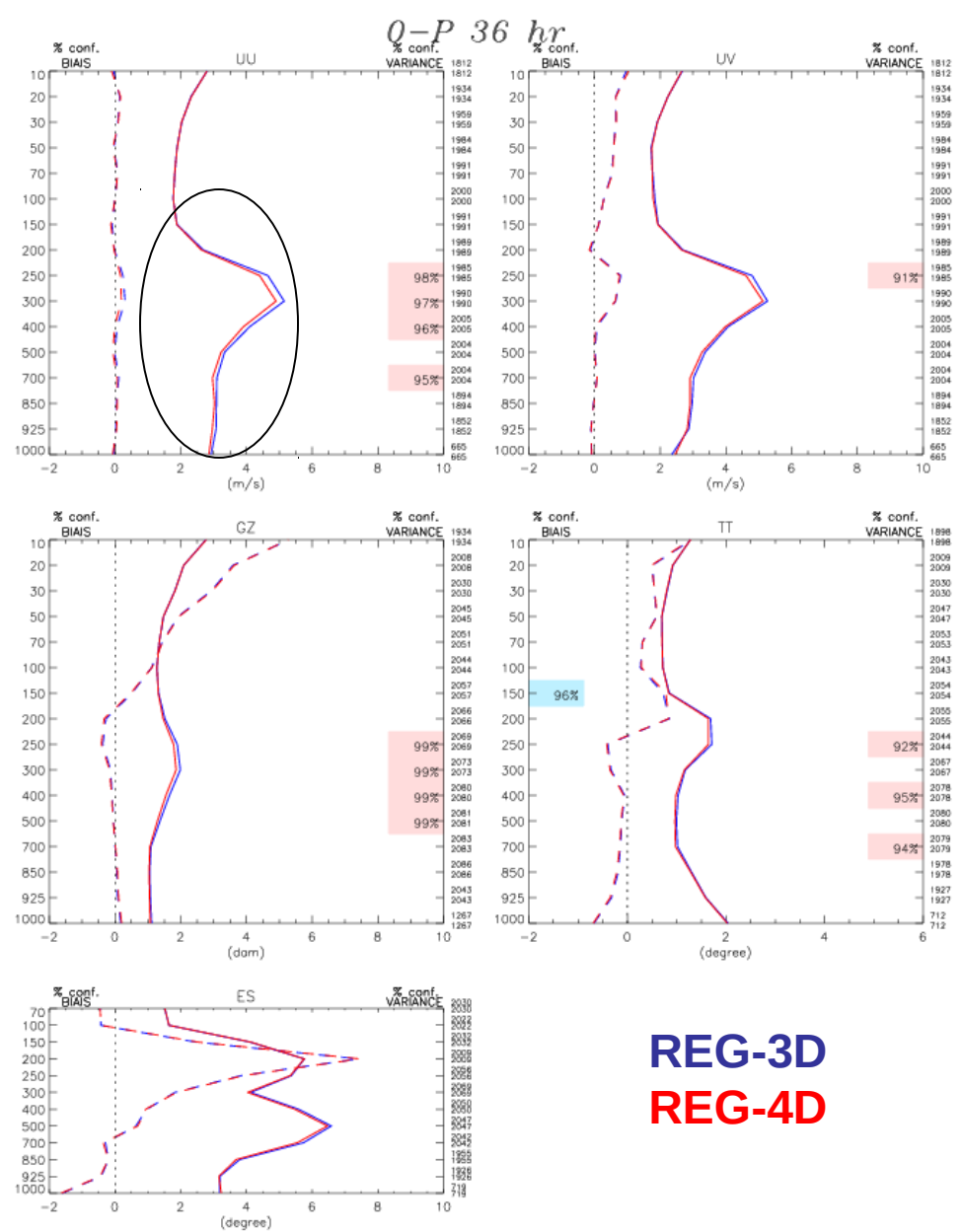
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◇	—	E-T m_uu_04B_regel040e08 ( 118 )
◇	- - -	BIAS m_uu_04B_regel040e08

Type : O-P 24 hr  
 Region : Arctique canadien  
 Lat-lon : ( 58N, 141W ) ( 90N, 50W )  
 Stat. communes



# Summer 2008 (118 cases) 36-h

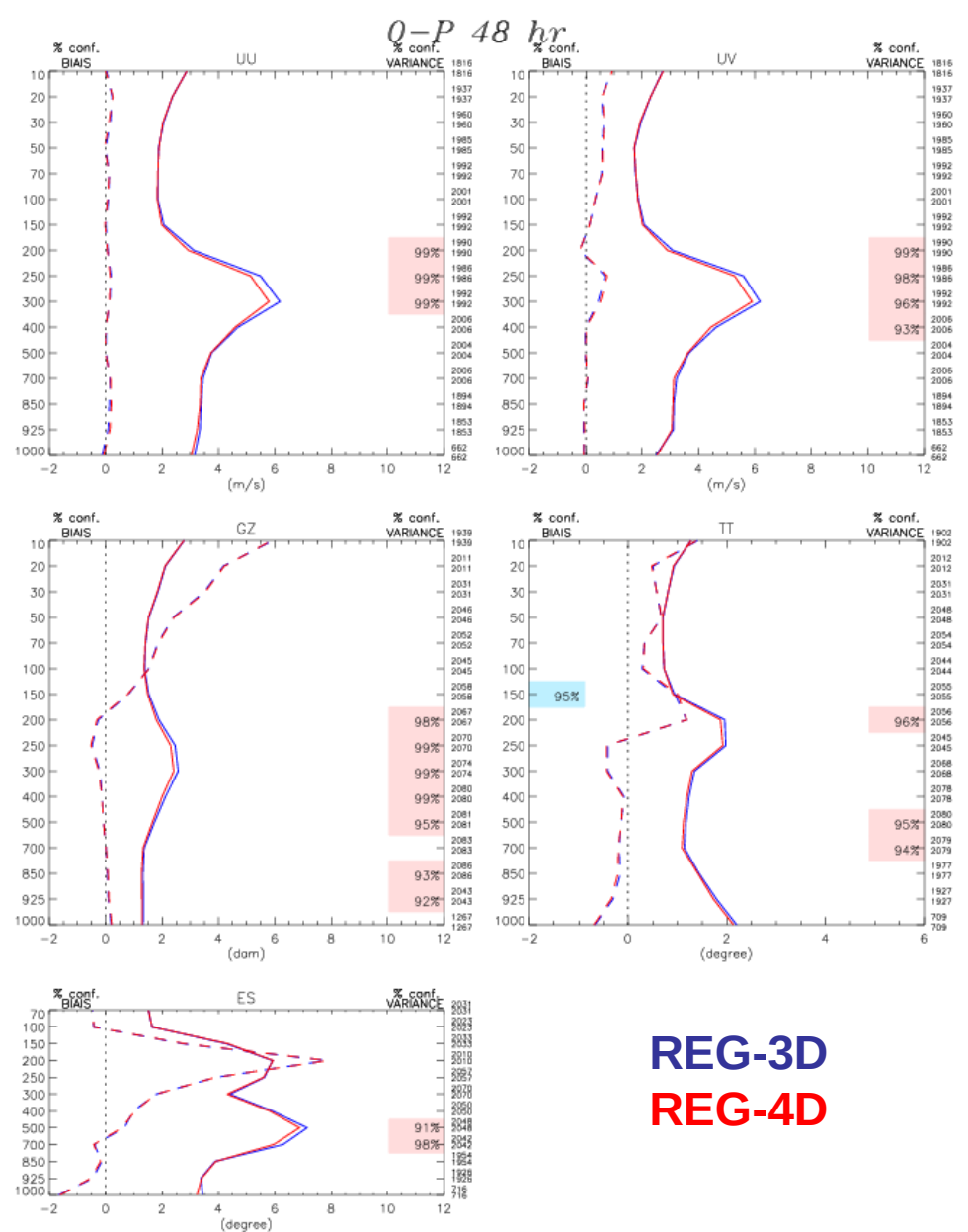
## Arctic



Type : O-P 36 hr  
 Region : Arctique canadien  
 Lat-lon : ( 58N, 141W ) ( 90N, 50W )

# Summer 2008 (118 cases) 48-h

## Arctic



**REG-3D**  
**REG-4D**

◇	—	E-T m_uo_048_regelaave08 ( 118 )
◇	- - -	BIAIS m_uo_048_regelaave08
◇	—	E-T m_uo_048_regel040e08 ( 118 )
◇	- - -	BIAIS m_uo_048_regel040e08

Type : 0-P 48 hr  
 Region : Arctique canadien  
 Lat-lon : ( 58N, 141W ) ( 90N, 50W )  
 Stat. communes

# Verifications against G2 4D-Var Analyses

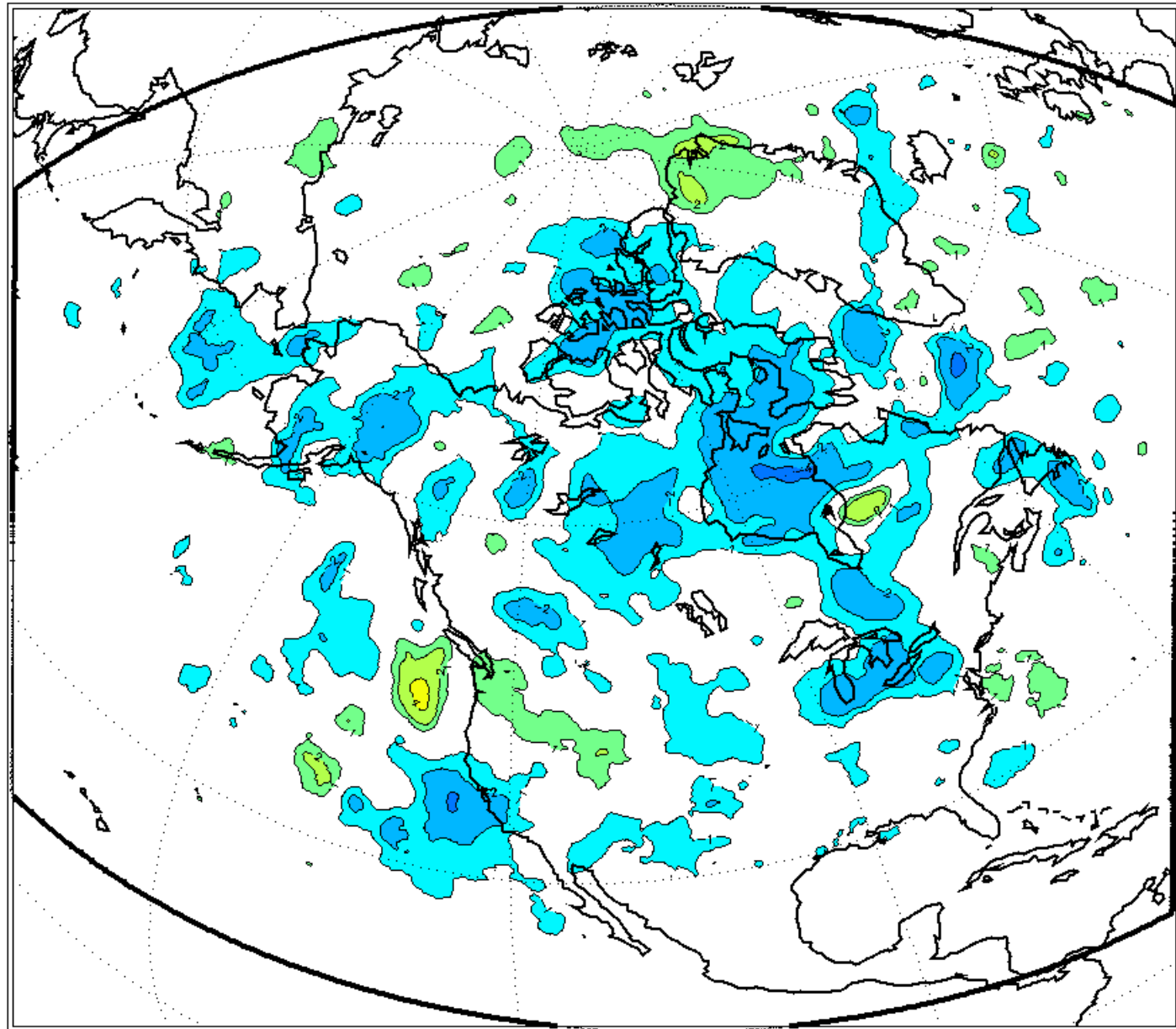
48-h DIFF RMSE (m)  
GZ-500 hPa

Winter-2009

Blue:  
4D-Var is better

DIFF RMSE IN METERS: REGEL040H09 MINUS REGELAAVH09 GZ 500 hPa 48HR PROG

LAM = -0.26 DAM MAX = 4.88 DAM MIN = -4.61 DAM



# Verifications against G2 4D-Var Analyses

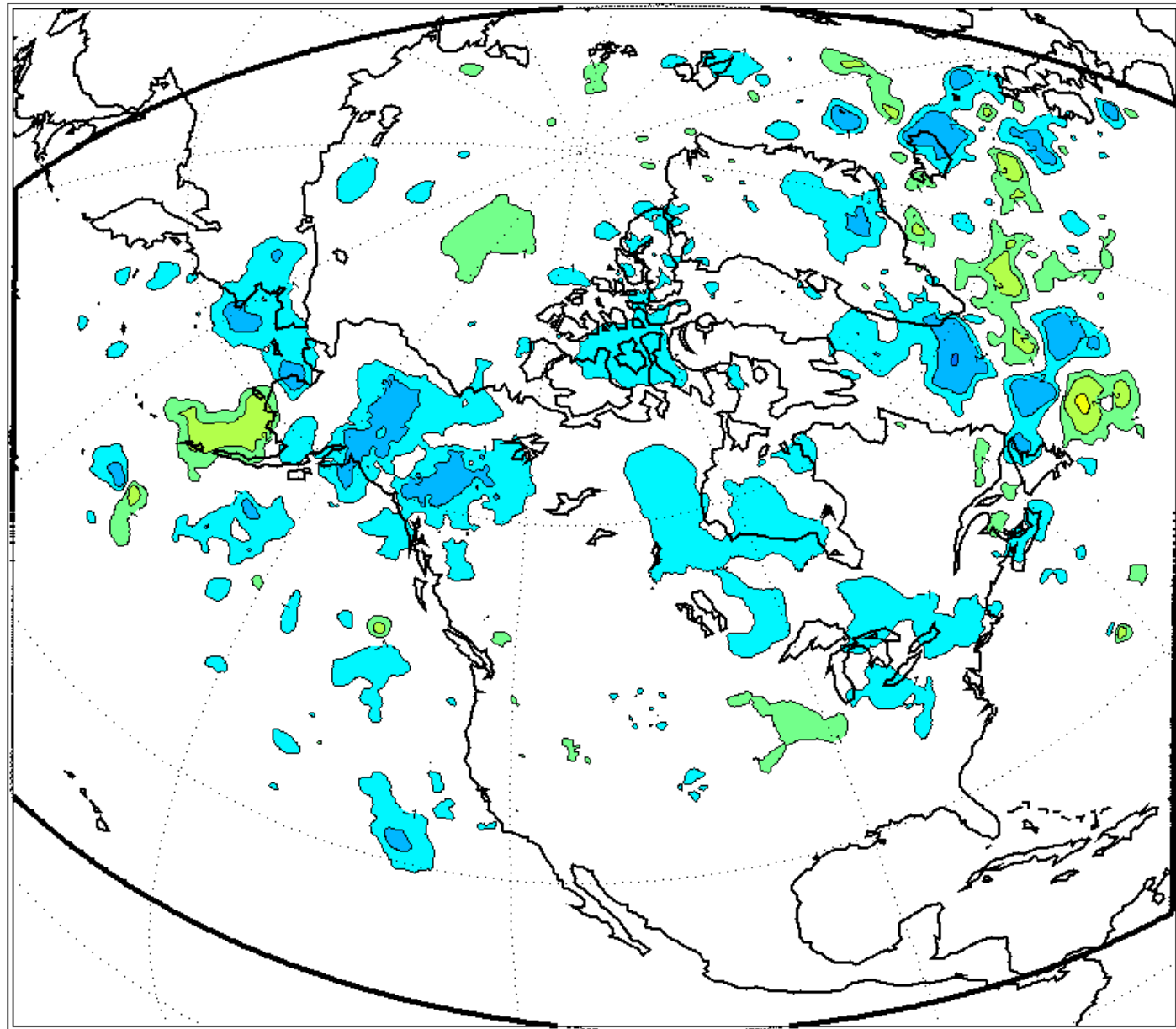
48-h DIFF RMSE (m)  
GZ-925 hPa

Winter-2009

Blue:  
4D-Var is better

DIFF RMSE IN METERS: REGEL040H09 MINUS REGELAAVH09 GZ 925 hPa 48HR PROG

LAM = -0.12 DAM MAX = 4.53 DAM MIN = -4.20 DAM



# Verifications against G2 4D-Var Analyses

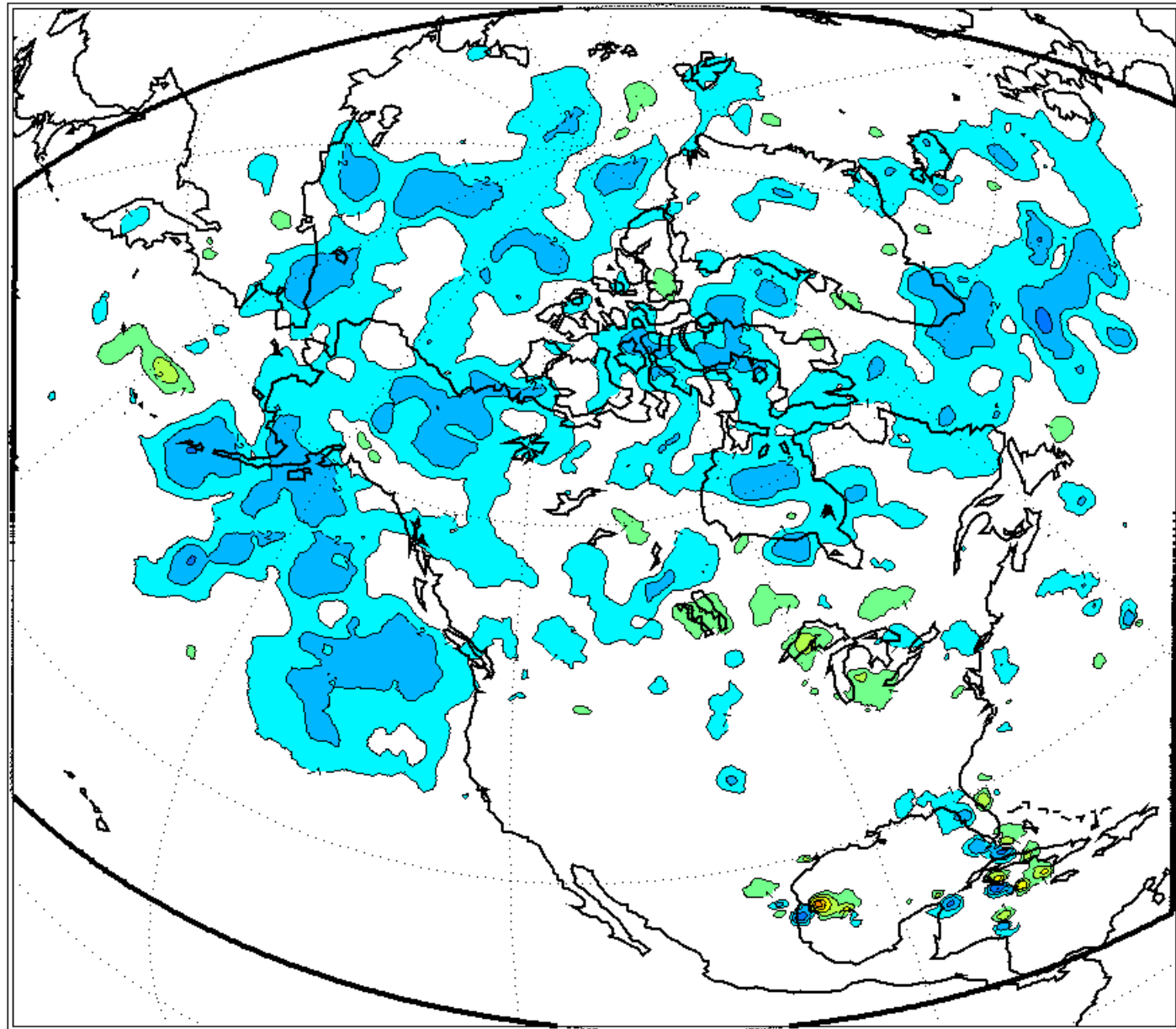
48h DIFF RMSE (m)  
GZ-500 hPa

Summer-2008

Blue:  
4D-Var is better

DIFF RMSE IN METERS: REGEL040E08 MINUS REGELA4VE08 GZ 500 hPa 48HR PROG

LAM1 = -0.36 DAM MAX = 15.64 DAM MIN = -8.06 DAM



# Verifications against G2 4D-Var Analyses

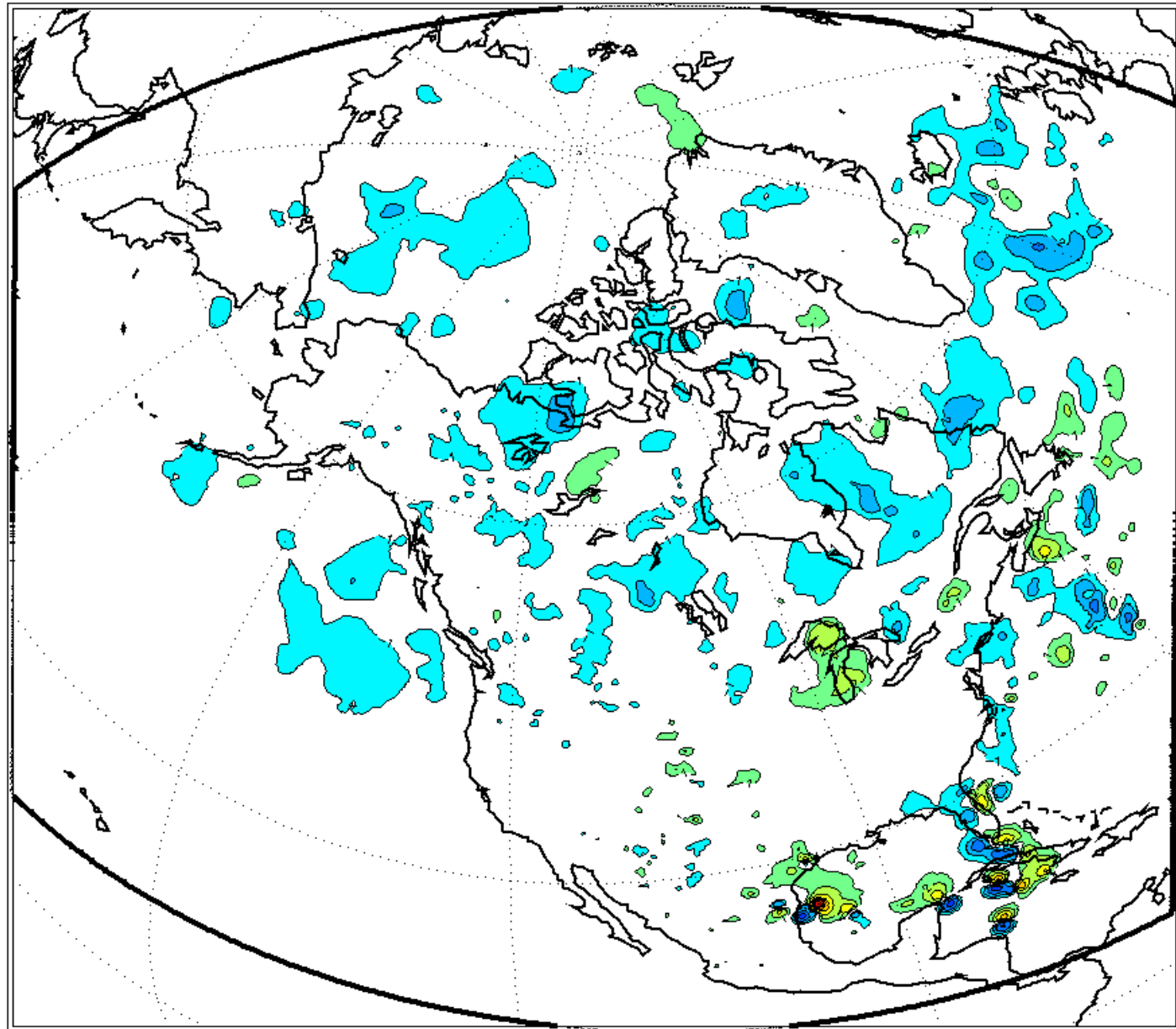
48h DIFF RMSE (m)  
GZ-925 hPa

Summer-2008

Blue:  
4D-Var is better

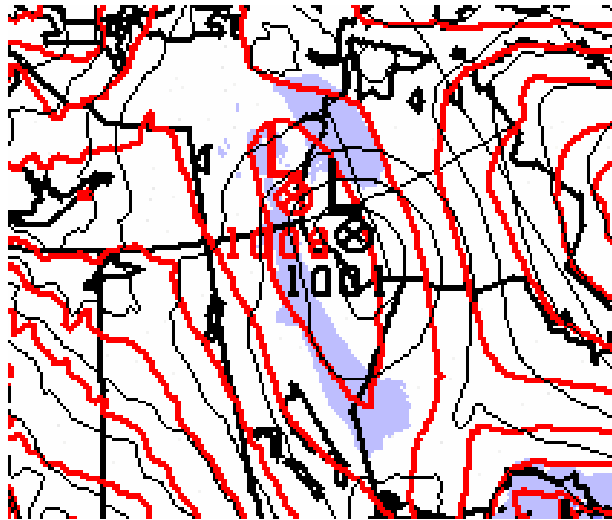
DIFF RMSE IN METERS: REGEL040E08 MINUS REGELAAVE08 GZ 925 hPa 48HR PROG

LAM = -0.13 DAM MAX = 24.31 DAM MIN = -11.35 DAM

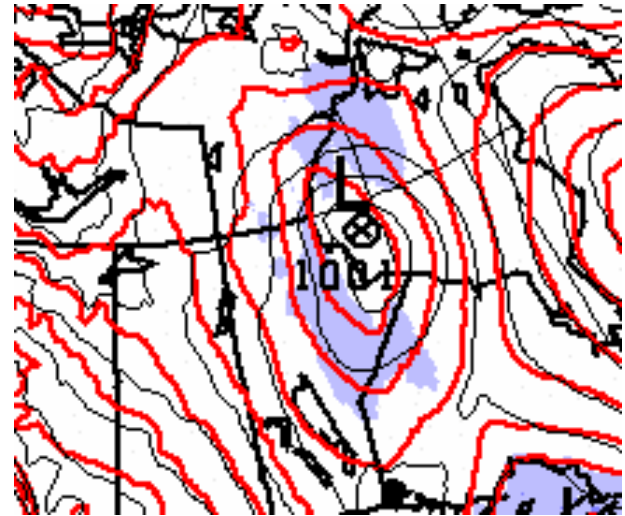


48h Forecast from 16 Jan 2009 Analysis

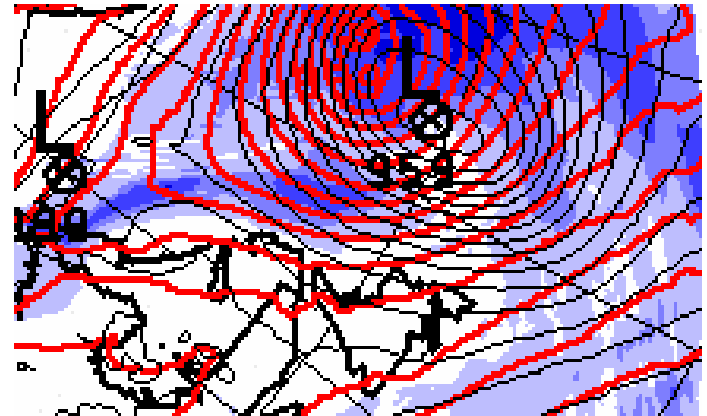
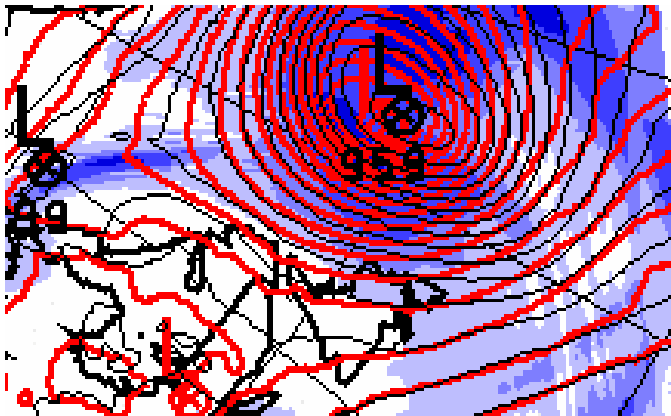
**REG-3D**



**REG-4D**

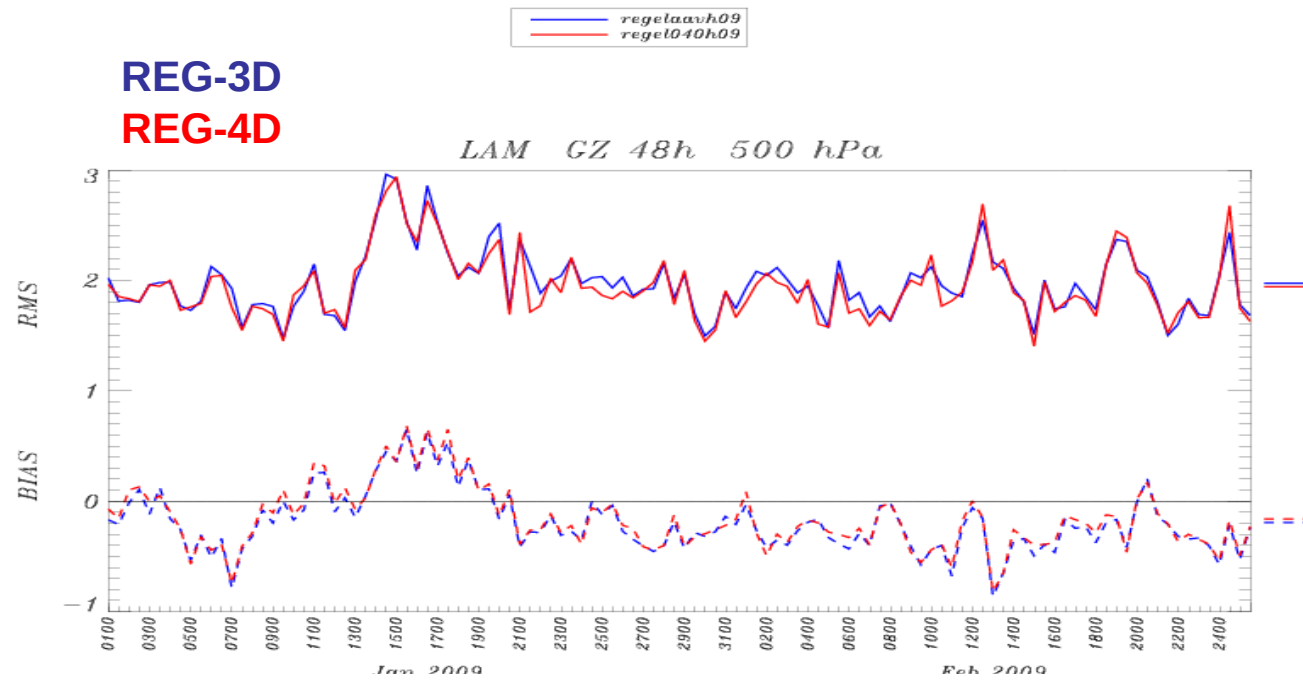


48h Forecast from 31 Jan 2009 Analysis

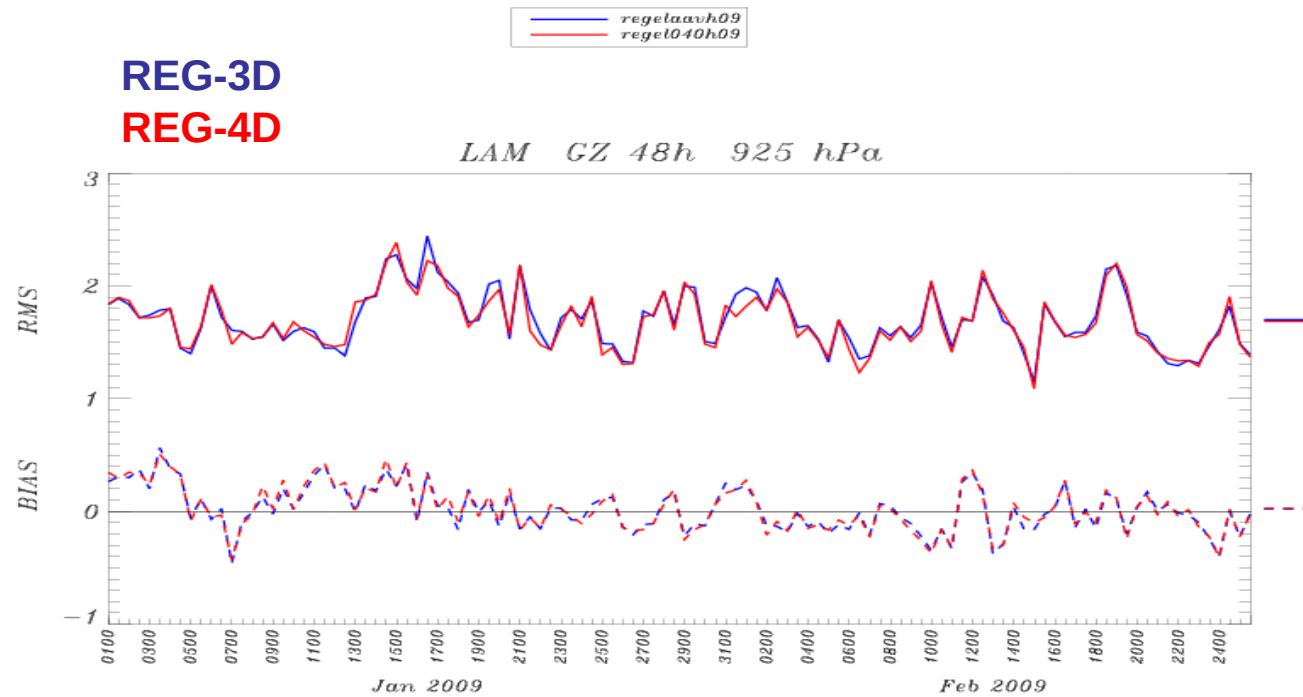


# Winter 2009 48h Forecast

GZ-500 hPa



GZ-925 hPa

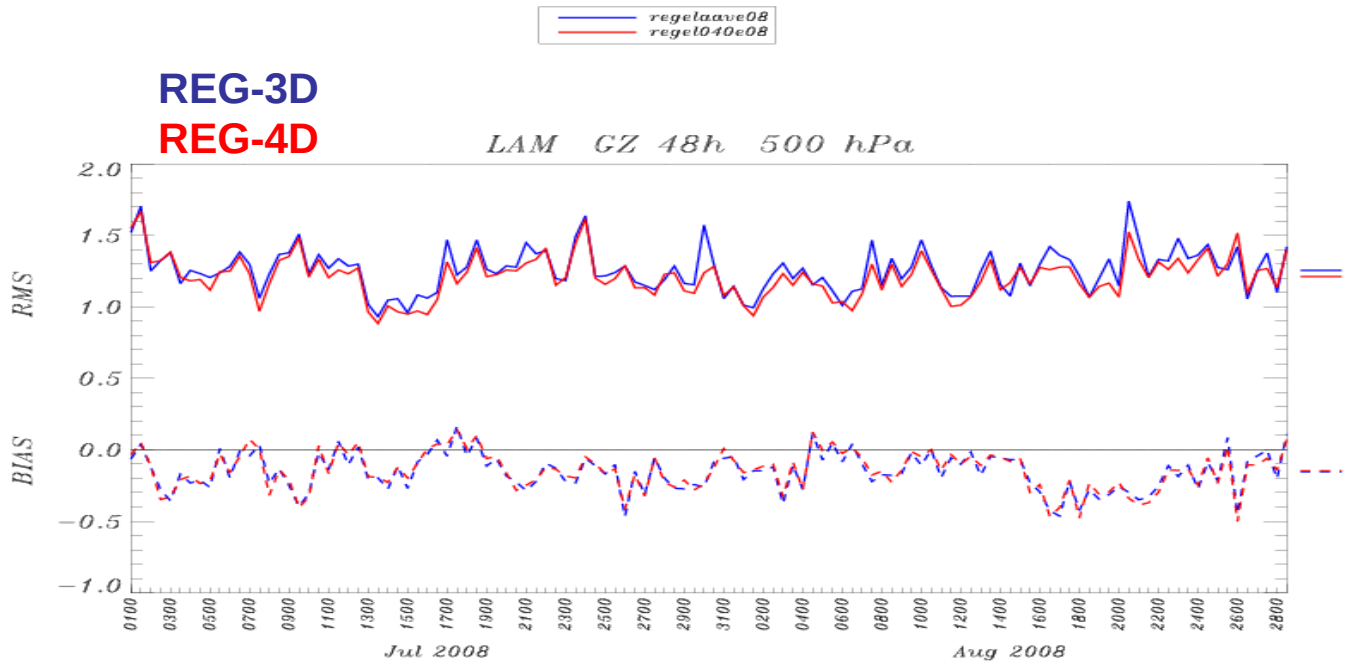




# Summer 2008 48h Forecast

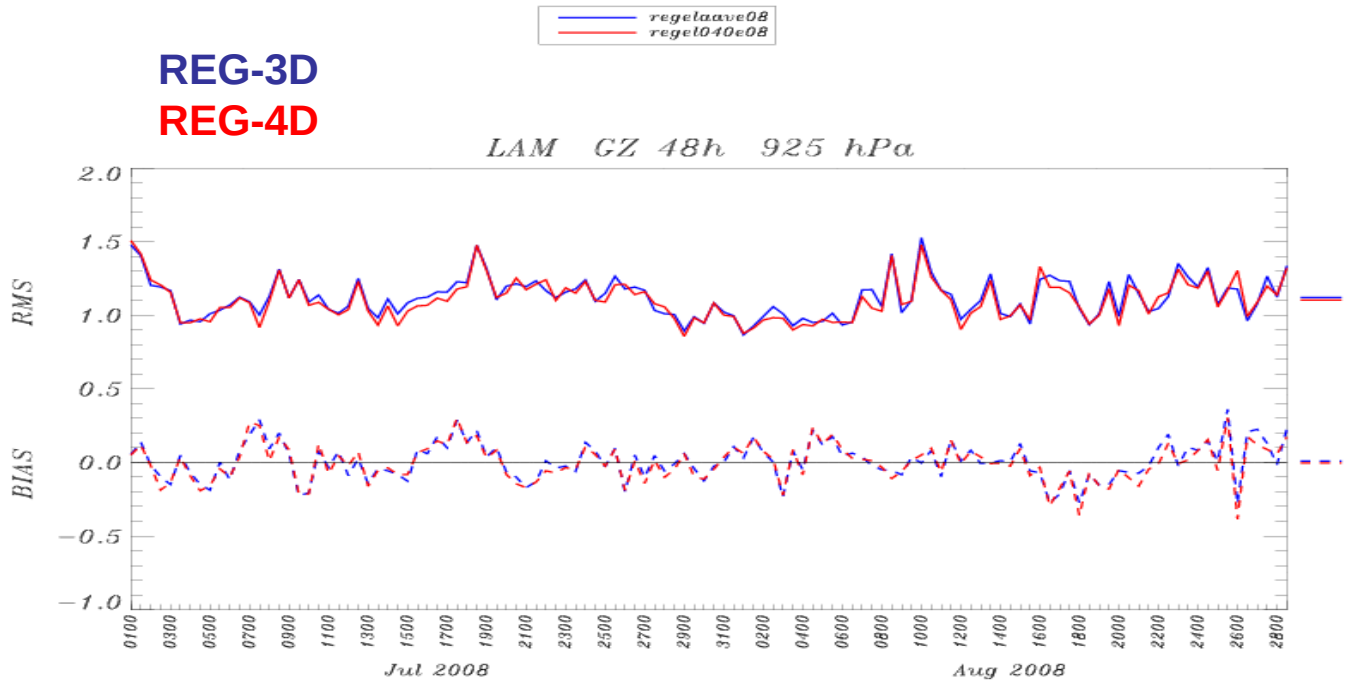
GZ-500 hPa

**REG-3D**  
**REG-4D**



GZ-925 hPa

**REG-3D**  
**REG-4D**



# SUMMER-2008

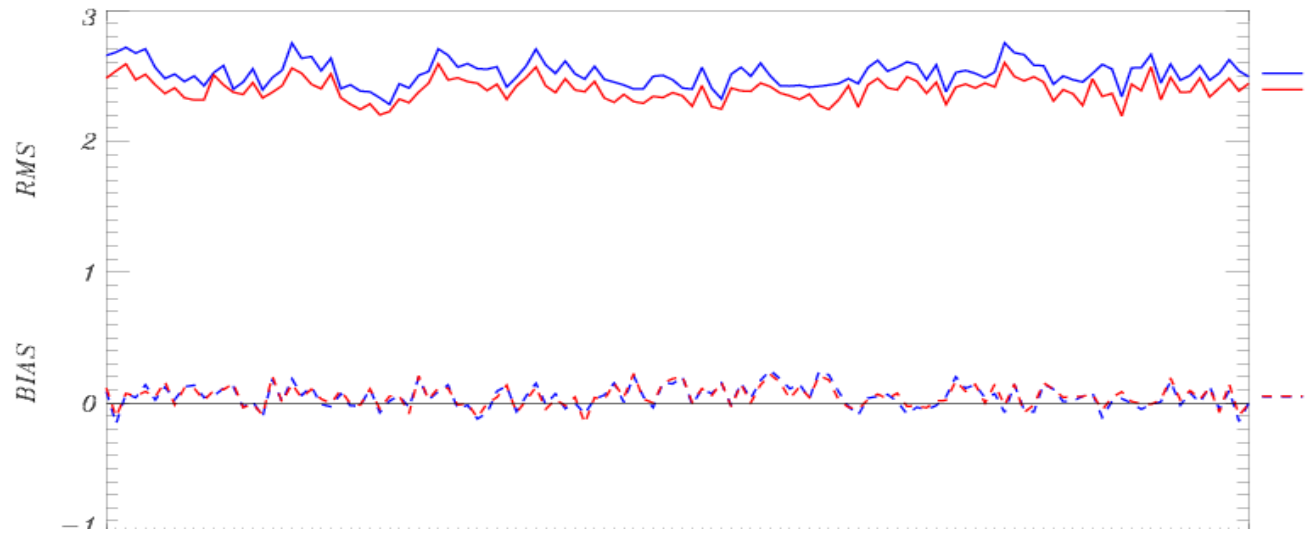
## 12h Forecast

UV-500 hPa

**REG-3D**  
**REG-4D**

— regelaave08  
— regel040e08

LAM UV 12h 500 hPa

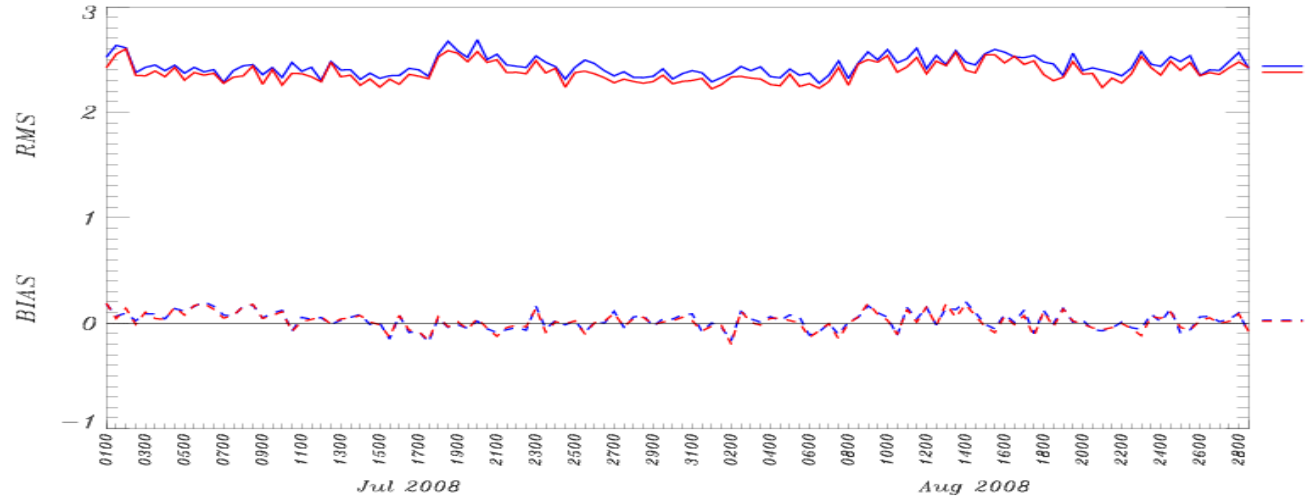


UV-925 hPa

**REG-3D**  
**REG-4D**

— regelaave08  
— regel040e08

LAM UV 12h 925 hPa



# SUMMER 2008 SHEF All of USA

00-24h

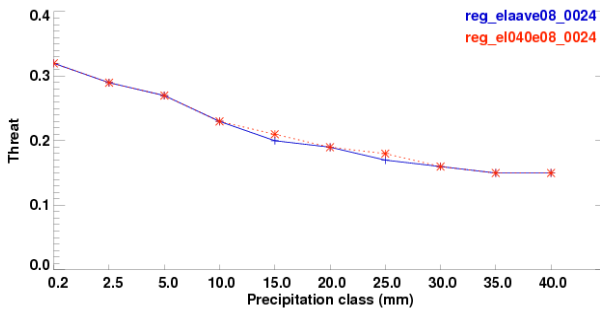
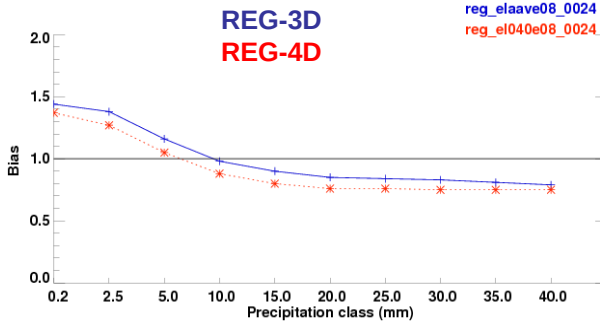
12-36h

24-48h

## 24 hours precipitation forecast verification against observation

SHEF network data for valid time 12z

00 to 24 hours forecast fm 12Z run only All of USA  
e08

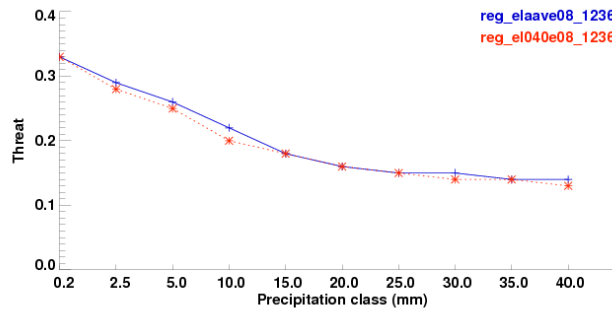
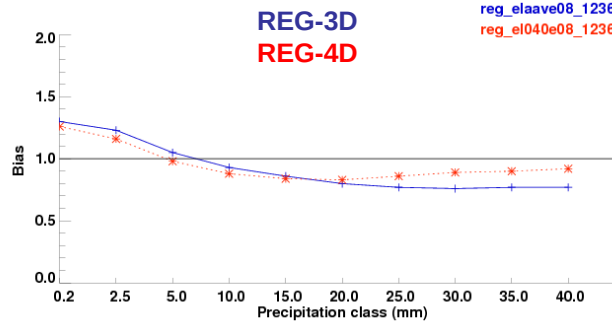


Number of observation  
112668 68410 54295 34623 23601 16863 12111 8917 6640 4991  
112668 68410 54295 34623 23601 16863 12111 8917 6640 4991

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

SHEF network data for valid time 12z

12 to 36 hours forecast fm 00Z run only All of USA  
e08

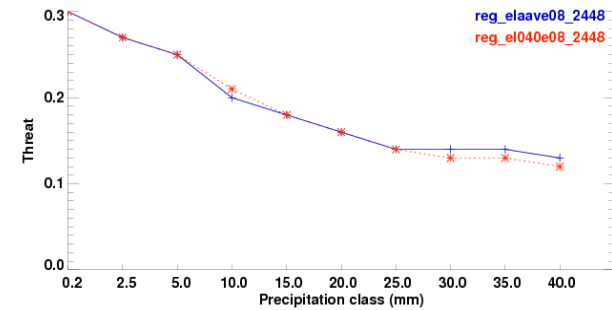
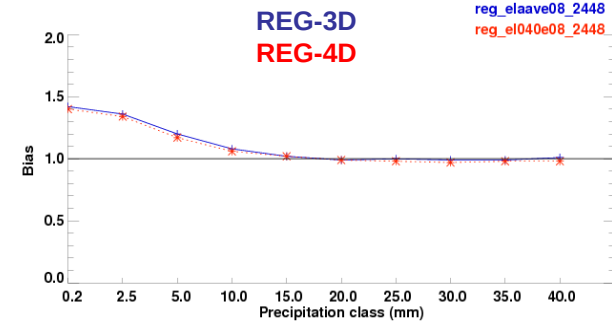


Number of observation  
112668 68410 54295 34623 23601 16863 12111 8917 6640 4991  
112668 68410 54295 34623 23601 16863 12111 8917 6640 4991

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

SHEF network data for valid time 12z

24 to 48 hours forecast fm 12Z run only All of USA  
e08



Number of observation  
111600 67953 53976 34455 23497 16801 12077 8891 6622 4977  
111600 67953 53976 34455 23497 16801 12077 8891 6622 4977

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

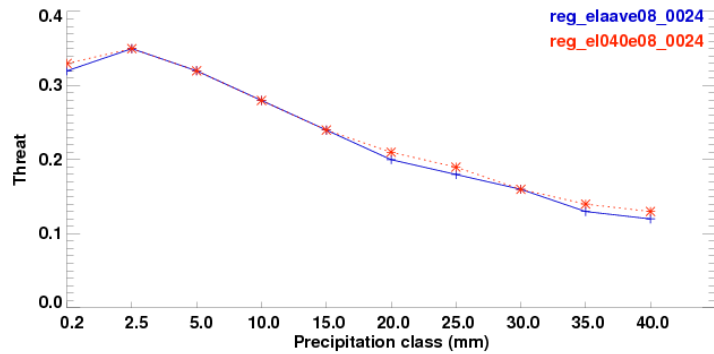
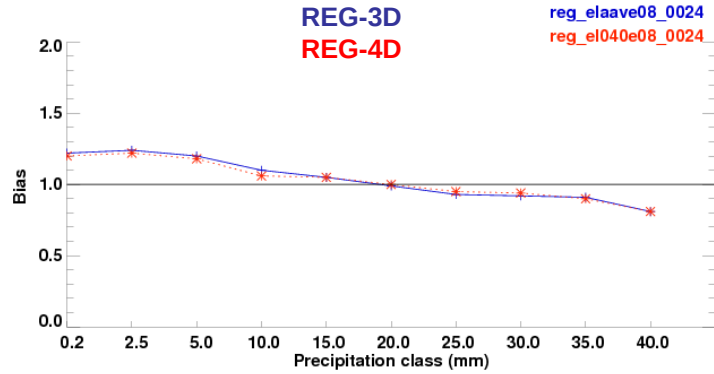
# SUMMER 2008 SYNOP North America

00-24h

24-48h

## 24 hours precipitation forecast verification against observation

Synoptic network data for valid time 00-12z  
00 to 24 hours forecast North AMERICA  
ete2008



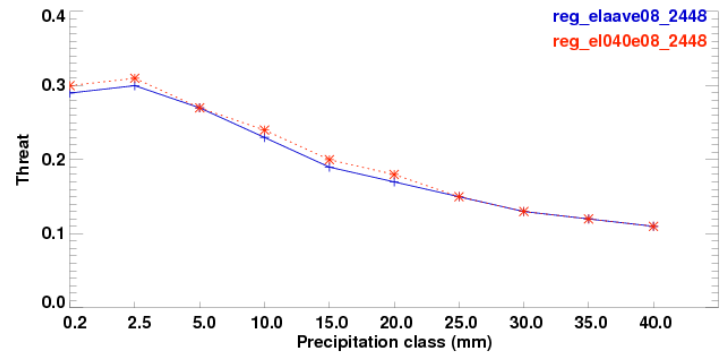
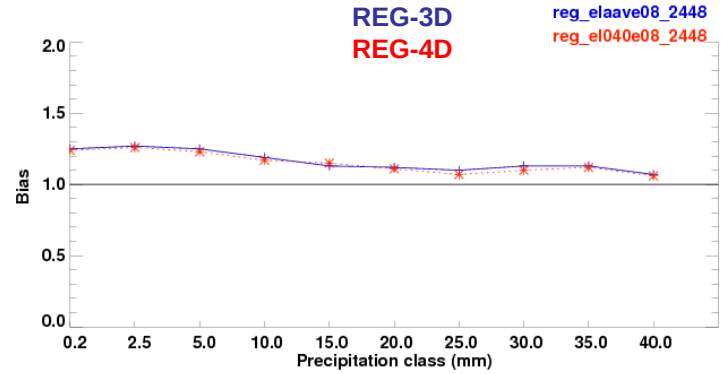
Number of observation

34007	17551	12077	6887	4208	2738	1857	1234	848	623
34007	17551	12077	6887	4208	2738	1857	1234	848	623

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

## 24 hours precipitation forecast verification against observation

Synoptic network data for valid time 00-12z  
24 to 48 hours forecast North AMERICA  
ete2008



Number of observation

33588	17386	11969	6840	4187	2730	1852	1230	844	619
33588	17386	11969	6840	4187	2730	1852	1230	844	619

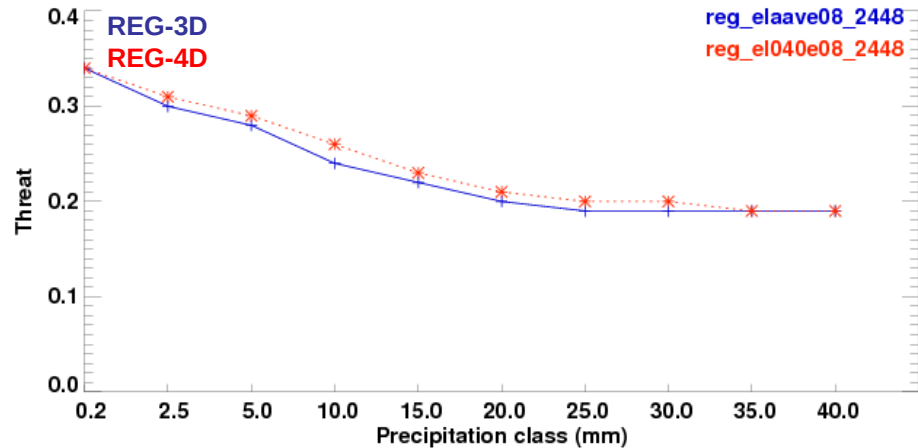
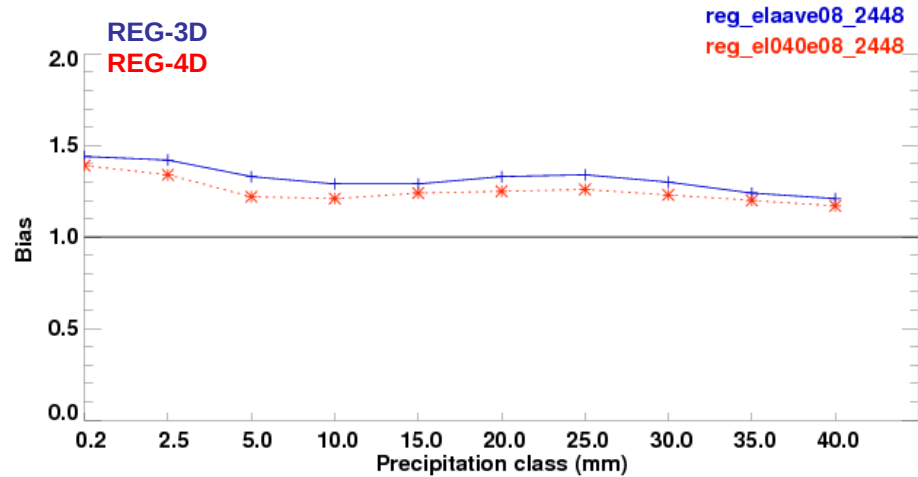
0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

# SUMMER 2008 SHEF-East-Coast

24-48h, (118 cases)

## 24 hours precipitation forecast verification against observation

SHEF network data for valid time 12z  
24 to 48 hours forecast fm 12Z run only East Coast  
e08



Number of observation

33378	21819	17528	11211	7575	5251	3716	2716	2017	1491
33378	21819	17528	11211	7575	5251	3716	2716	2017	1491

Precipitation class (mm)	0.2	2.5	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
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# WINTER 2009 SHEF All of USA

00-24h

12-36h

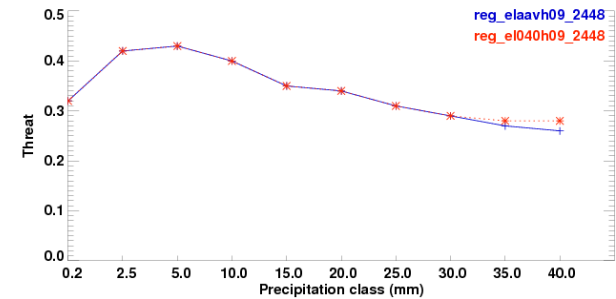
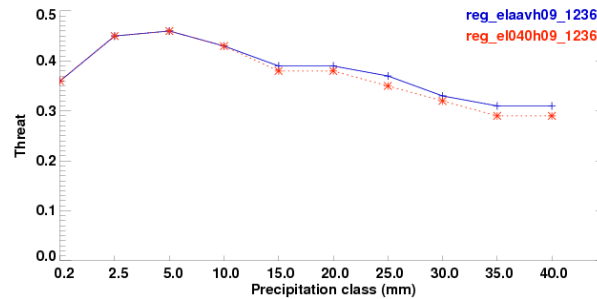
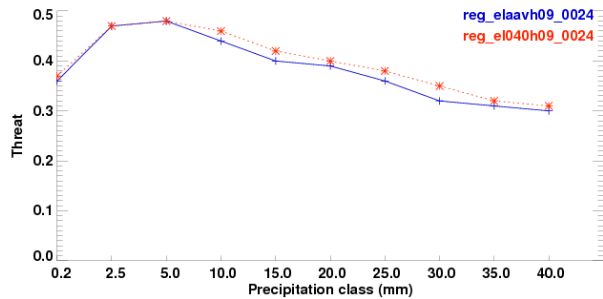
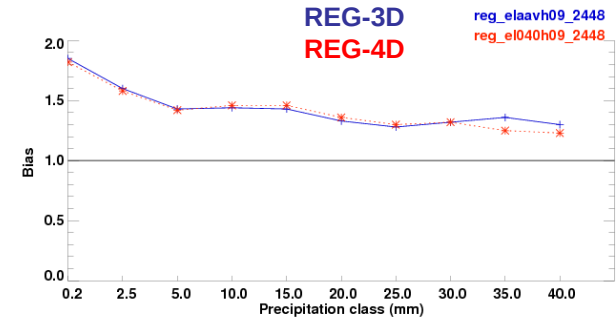
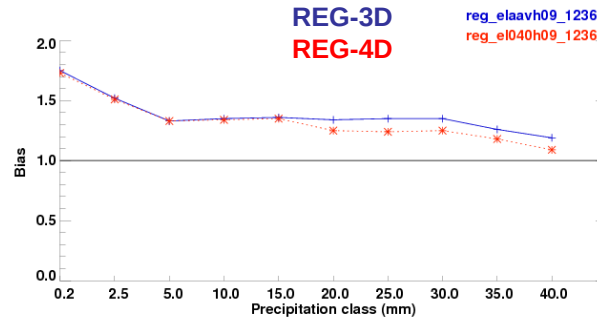
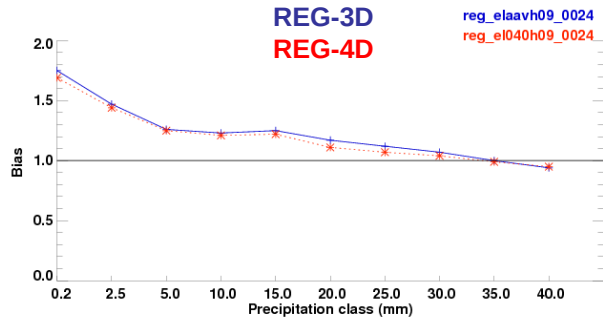
24-48h

24 hours precipitation forecast verification against observation 24 hours precipitation forecast verification against observation 24 hours precipitation forecast verification against observation

SHEF network data for valid time 12z  
00 to 24 hours forecast fm 12Z run only All of USA  
h09

SHEF network data for valid time 12z  
12 to 36 hours forecast fm 00Z run only All of USA  
h09

SHEF network data for valid time 12z  
24 to 48 hours forecast fm 12Z run only All of USA  
h09



Number of observation

114410	59384	44499	23869	14013	9097	6002	4038	2895	2125
114410	59384	44499	23869	14013	9097	6002	4038	2895	2125

Number of observation

114410	59384	44499	23869	14013	9097	6002	4038	2895	2125
114410	59384	44499	23869	14013	9097	6002	4038	2895	2125

Number of observation

113090	58739	43941	23442	13692	8837	5803	3879	2755	2015
113090	58739	43941	23442	13692	8837	5803	3879	2755	2015

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

0.2 2.5 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0  
Precipitation class (mm)

# Temps d'exécution

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- Le temps d'exécution de l'assimilation dans la passe parallèle régionale Strato-2B est de
  - 25 minutes
- Avec les optimisations que nous avons faites récemment au REG-4D, on arrive à un timing de
  - 30 minutes

— Le 4D-Var comme tel prend 17 minutes:

- Utilisation de sous-répertoires dans le répertoire d'échange
- Autres optimisations possibles par la suite

Il suffirait donc d'utiliser un cut-off 5 minutes plus court pour pouvoir tourner un REG-4D.

Il passerait de +2h05 à +2h.

Évidemment, ce ne sera plus un enjeu lors du passage à la nouvelle machine

# Enjeux pour l'implémentation

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- Les changements à faire à la passe opérationnelle sont extrêmement simples.
- On peut voir ceci comme des changements de haut-niveau à la configuration.
- Le seul enjeu non-trivial est la modification au cut-off. Ceci se gère facilement.
- On estime le temps nécessaire pour l'implémentation de 1 à 2 semaines.



## Travaux en cours et a venir

### REG4D\_V3 (2011-2012)

- **Ground\_based GPS** (Stephen MacPherson, J. St-James, S. Laroche)
- **MPI upgrades** (Bin He, Ervig Lapalme, Monique Tanguay, Michel Valin)
- **Vertical Staggering Analysis** (Luc Fillion, Mat Reszka)
- **GEM-4 (LAM+Driver) + GEM-10 km** (Paul Vaillancourt et al.)

**REn\_KF** (Luc Fillion, Mat Reszka, J. Someoneelse, 2011) (METAREAS)

### REG4D\_V4

- **TL-INMI-Diabatic** (Fillion et al 2007) Amelioration de la precip 0-24h.
- **Jb\_Ens** (Buehner 2008) Covariances d'erreur de previ ameliorees
- **Analyse avec Pilotage Vertical a 35 hPa** (McTaggart et al. 2010)  
=> Augmentation de resolution verticale (Previ & Analyse)

\_\_\_\_\_ FIN \_\_\_\_\_