

Asimilarea datelor radar intr-un model numeric de prognoza atmosferica

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Definitie

- Climate is what you expect,
weather is what you get”
– Mark Twain

Implicatii “ingineresti” Proiectarea sistemelor

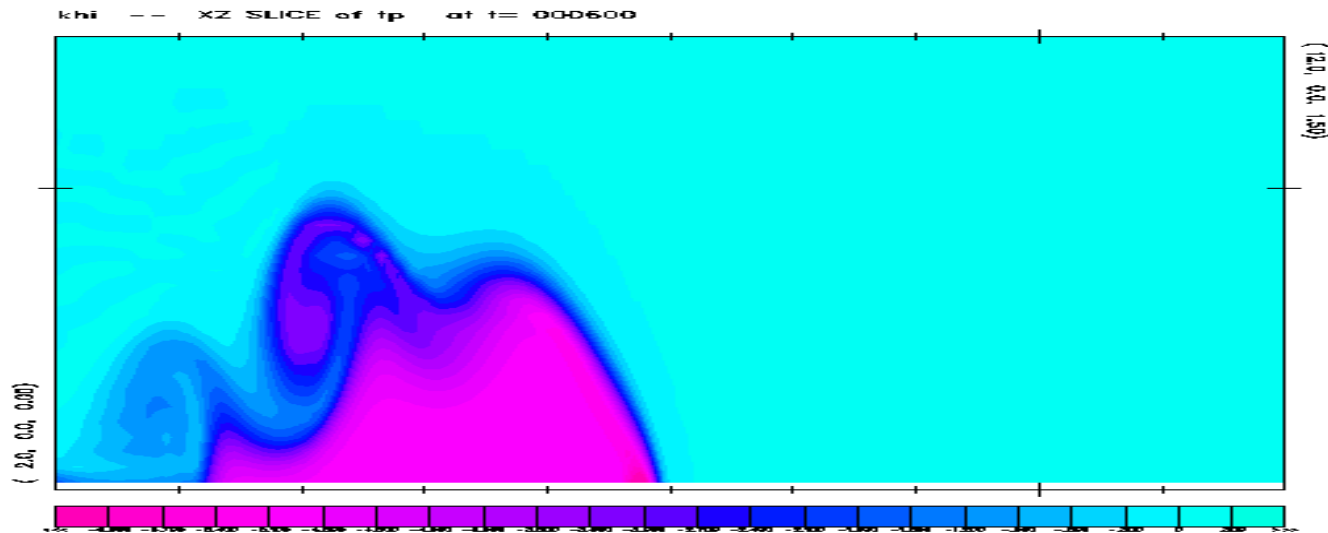


Implicatii “ingineresti” Conducerea si controlul sistemelor



Implicatii “ingineresti” mixte

Proiectarea, conducerea controlul sistemelor



Control optimal

Formulare matematica

$$\frac{d\mathbf{Y}}{dt} = F(\mathbf{Y}, \mathbf{W}) \text{ pe } \Omega \times (0, T)$$

$$\mathbf{Y}[t = 0] = \mathbf{U}$$

$$\mathbf{Y}_{\partial\Omega} = \mathbf{V}$$

$$J(\mathbf{Y}(\mathbf{U}, \mathbf{V}, \mathbf{W}, \mathbf{Y})) = \frac{1}{2} \langle \mathbf{Y} - \bar{\mathbf{Y}}, \mathbf{Y} - \bar{\mathbf{Y}} \rangle_{\Omega \times (0, T)}$$

Solutie

- Multiplicatori Lagrange
- Model adjunct

Filtrul Kalman

- Variabila $\mathbf{X}(k+1,k)$ si incertitudinea ei sunt determinate din $\mathbf{X}(k)$ folosind model F
- $\mathbf{X}(k+1)$ este determinata din $\mathbf{X}(k+1,k)$, masuratoarea \mathbf{Z} si diverse masuri ale incertitudinii

$$\mathbf{X}_k = \mathbf{X}_{k+1|k} + \mathbf{K}(\mathbf{Z} - \mathbf{H}\mathbf{X}_{k+1|k})$$

$$\mathbf{K} = \mathbf{P}\mathbf{H}^T [\mathbf{H}\mathbf{P}\mathbf{H}^T + \mathbf{R}]^{-1}$$

- Algoritmul necesita evaluarea gradientului lui F

Filtrul Kalman bazat pe ansambluri statistice

- Similar filtrului Kalman conventional dar aplicat unui ansamblu de modele rulate in paralel
- Gradientul modelului este estimat statistic din analiza membrilor ansamblului
- Este echivalent cu o regresie liniara intre masuratori si variabilele modelului
- Este general si nu necesita implementari specifice modelului

Aplicatii in predictia inundatiilor

- Modelul numeric (Weather Research and Forecasting-WRF) este initializat folosind date produse de un model global cu rezolutie redusa
- WRF
 - rezolva ecuatiile Navier-Stokes
 - simuleaza interactiune a 6 specii de hidrometeori si ia in considerare impactul lor termic asupra atmosferei
 - Contine module de interactiune a atmosferei cu suprafata terestra (evaporatie, infiltratie, transfer de caldura, moment etc.)
- Informatie privind precipitatie (observatii radar si satelitare) sunt asimilate in WRF

Asimilarea datelor bazate pe un ansamblu statistic

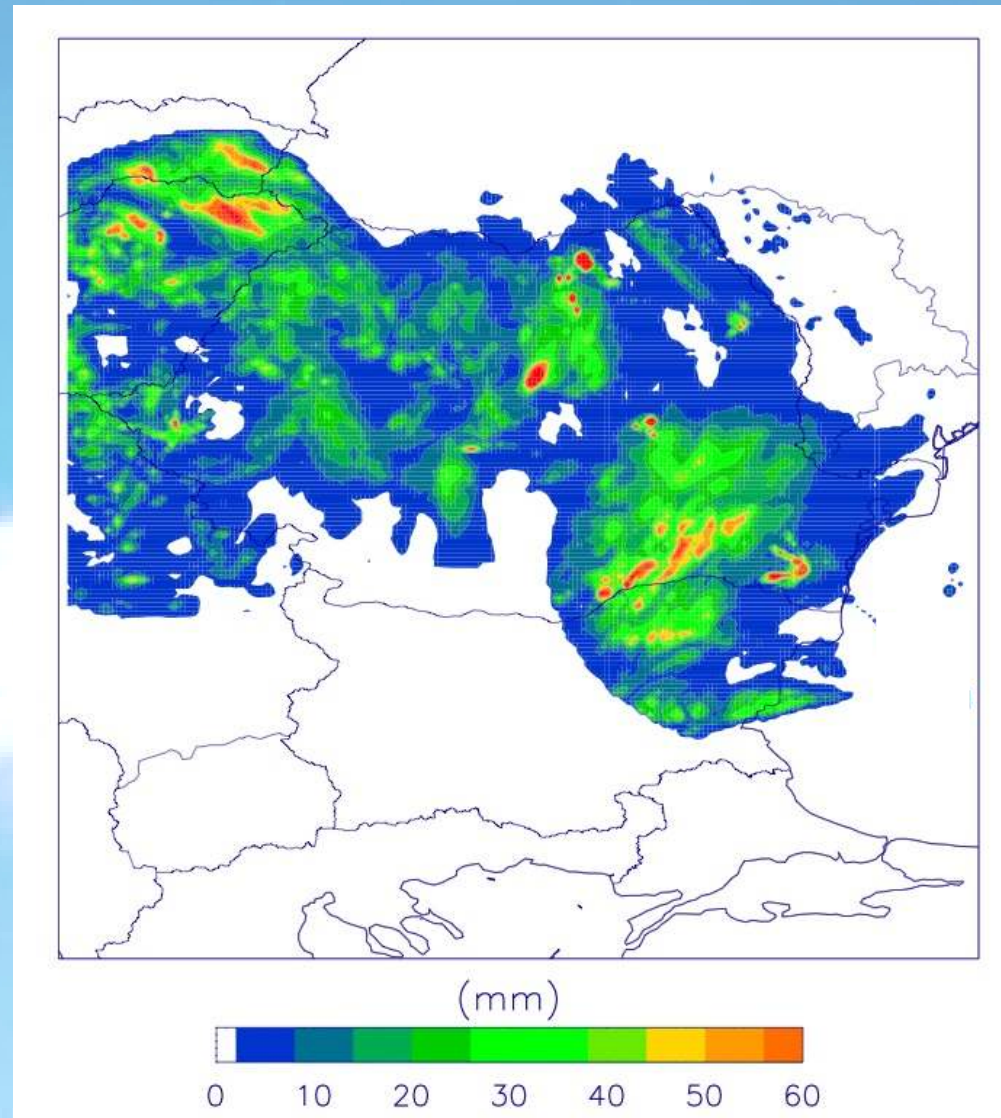
- Modelul utilizat este WRF 3.0
- Un ansamblu statistic continand 50 de membri este initializat pe 22 August, la 18:00 UTC si rulat pentru 27 de ore.
- Conditile initiale ale membrilor ansamblului sunt determinate folosind Functii Empirice Ortogonale (EOF)
 - Sapte zile de date furnizate the modelul GFS data sunt folosite pentru determinarea anomalilor EOF ale vitezelor, geopotentialului si umiditatii.
- Folosind o analiza bazata pe datele radar, ansamblul este reinitializat pe 23 August, la 18:00 UTC si o predictie a conditiilor atmosferice in intervalul 18:00UTC-03:00UTC este realizata

Asimilarea datelor

Detalii privind implementarea

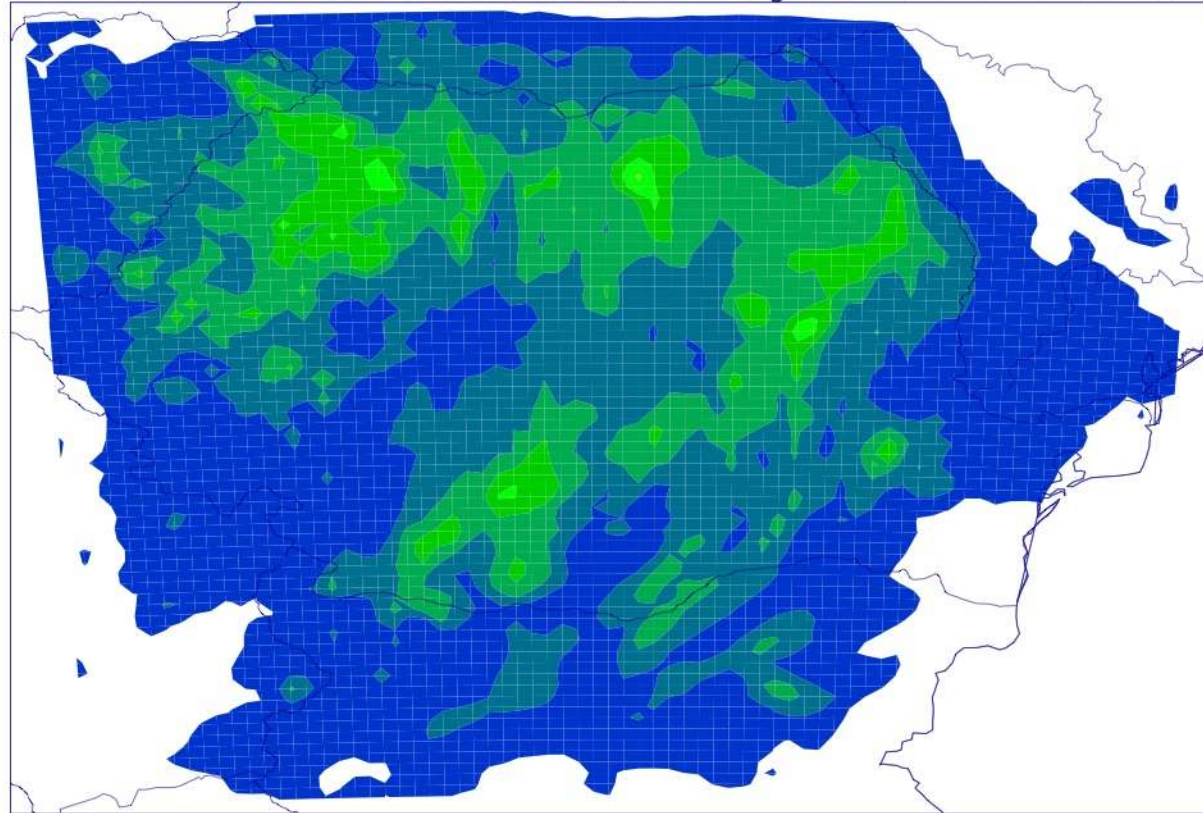
- Asimilarea datelor este realizata folosind un filtru Kalman in spatiul anomaliiilor EOF
 - Variabilele fizice sunt exprimate ca o combinatie liniara de anomalii EOF folosind descompunerea SVD (Singular Value Decomposition).
 - Coeficientii rezultati (care sunt mai putini decat numarul membrilor ansamblului) sunt actualizati folosind filtrul Kalman.
 - Coeficientii actualizati si anomaliiile EOFs sunt folositi pentru actualizarea variabilelor fizice.
- Implementarea permite realizarea unor combinatii statistice sau reinitializarea predictiilor.

24-hour radar rain accumulation starting 23 August at 00:00

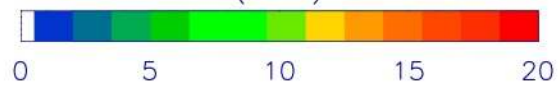


The initial ensemble forecast in the assimilation window

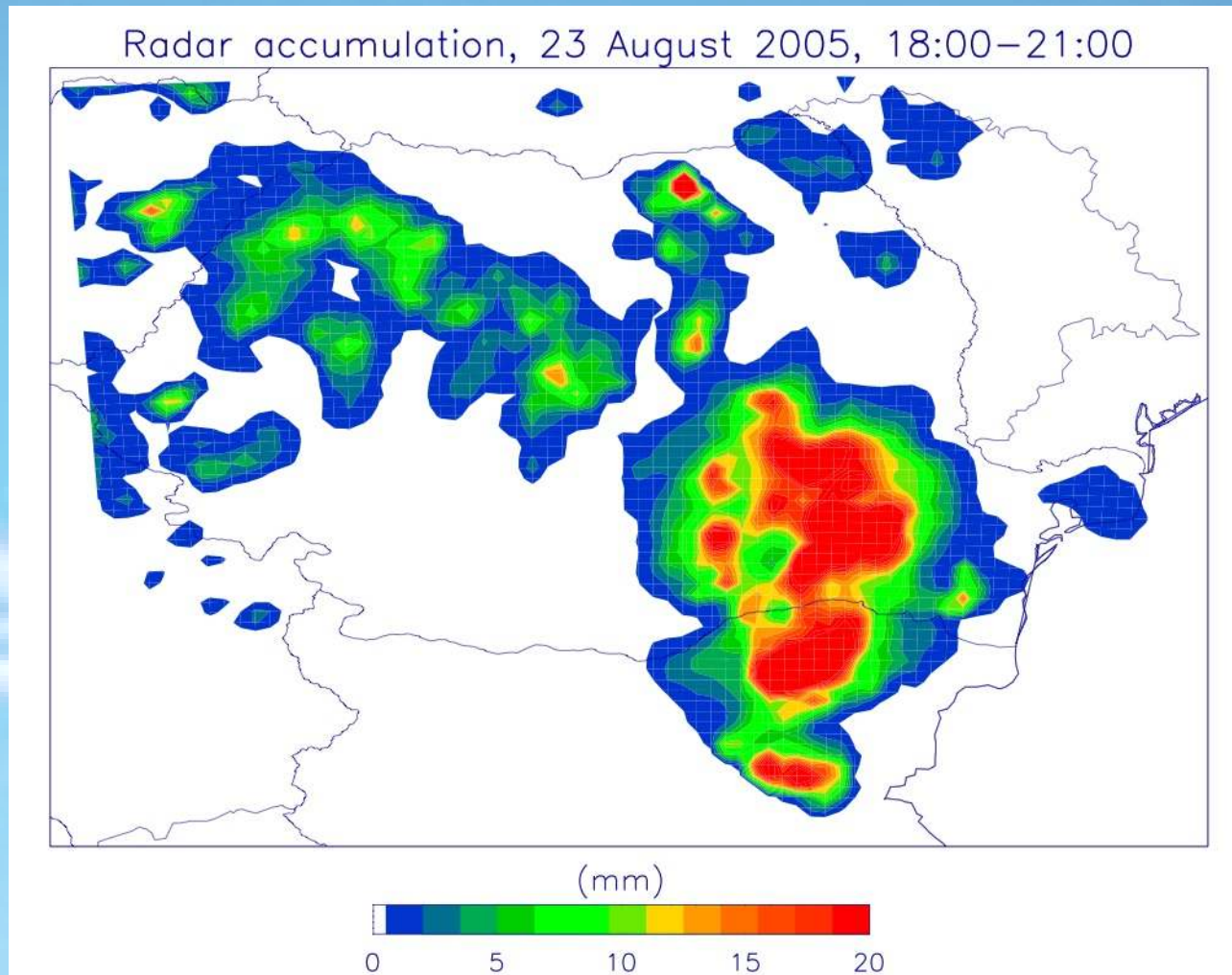
Accumulation standard deviation, 23 August 2005, 18:00–21:00



(mm)

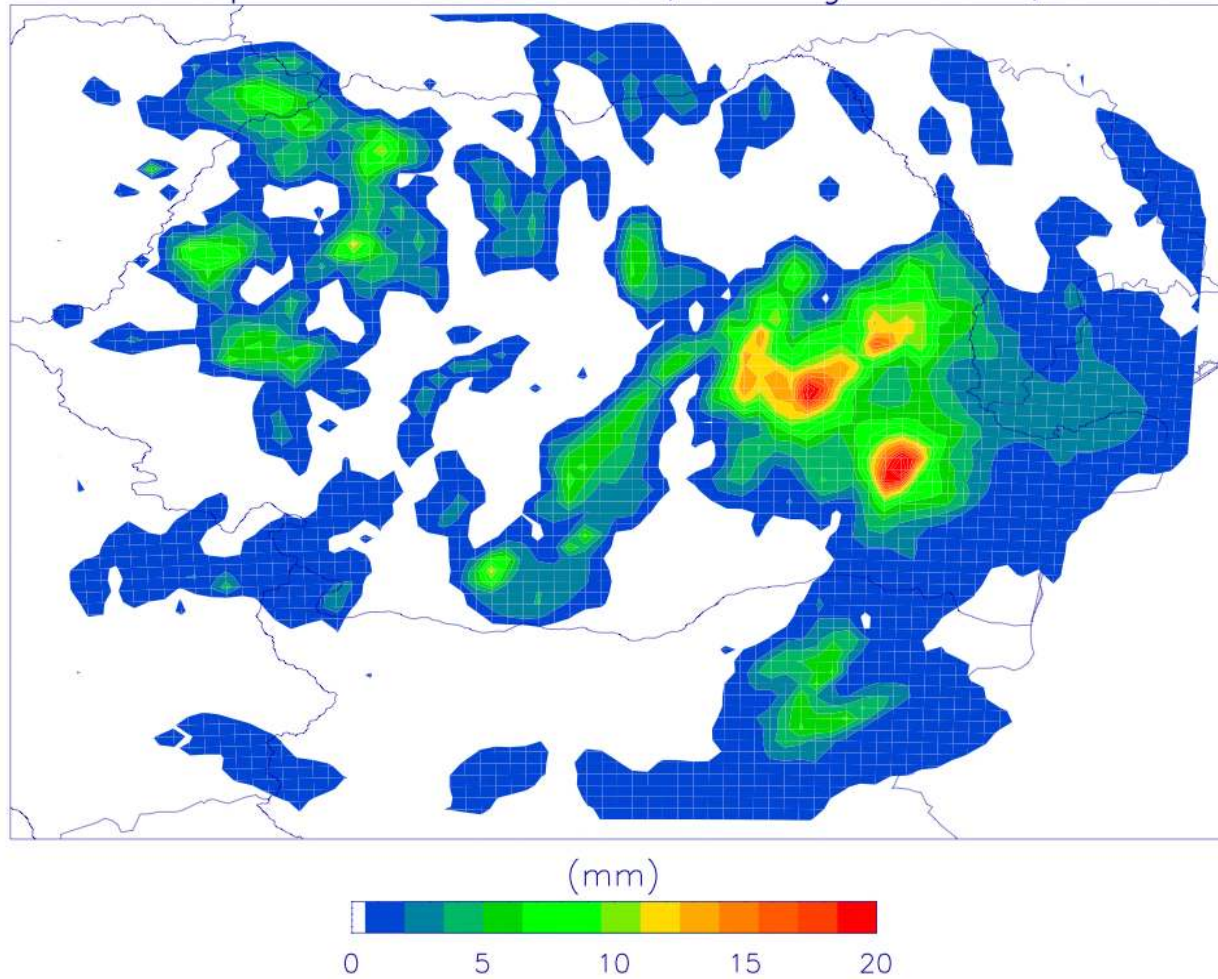


Radar rain accumulation in the assimilation window

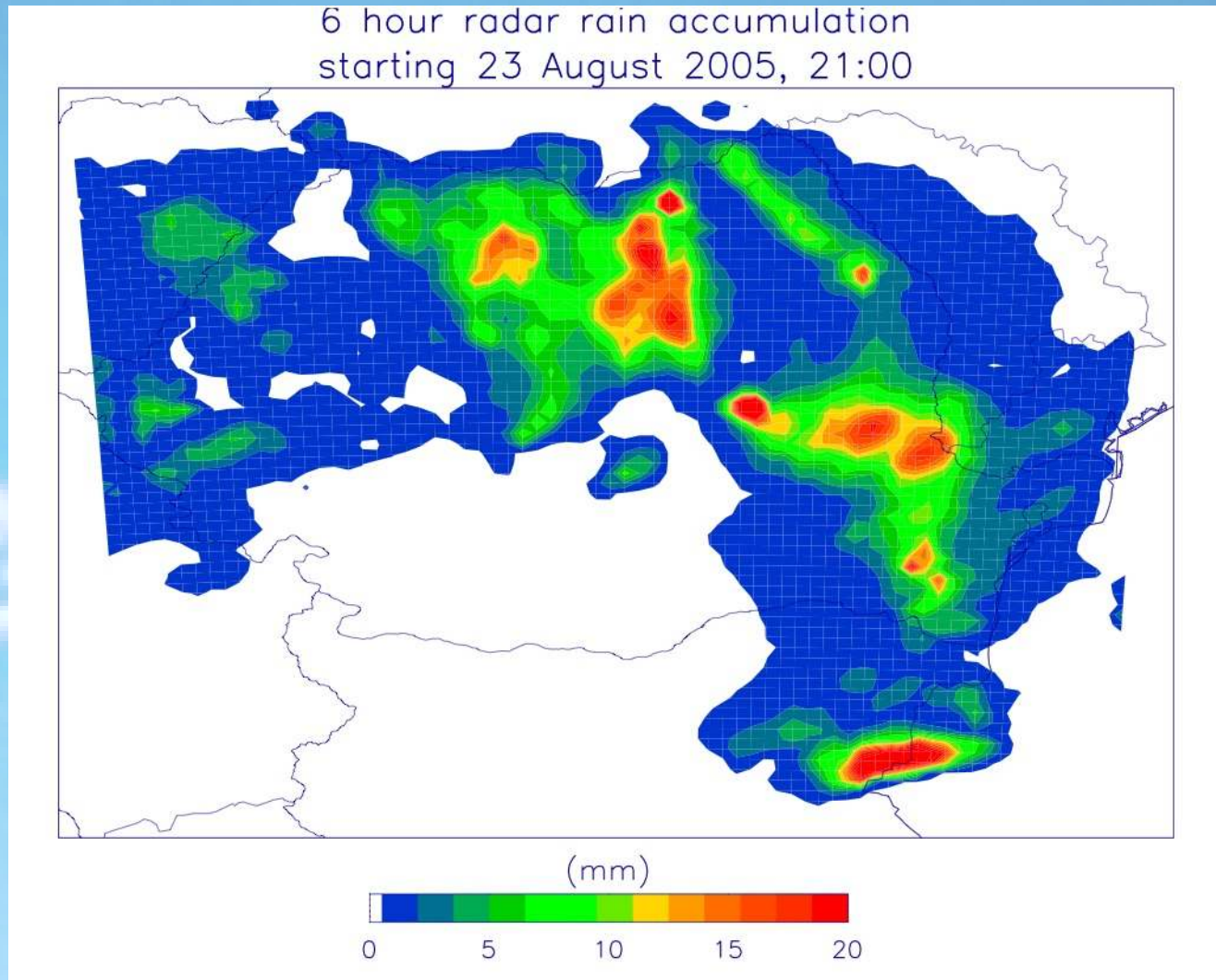


3 hour statistical forecast using the radar observation projection into the ensemble space

Ensemble extrapolated accumulation, 23 August 2005, 21:00–24:00

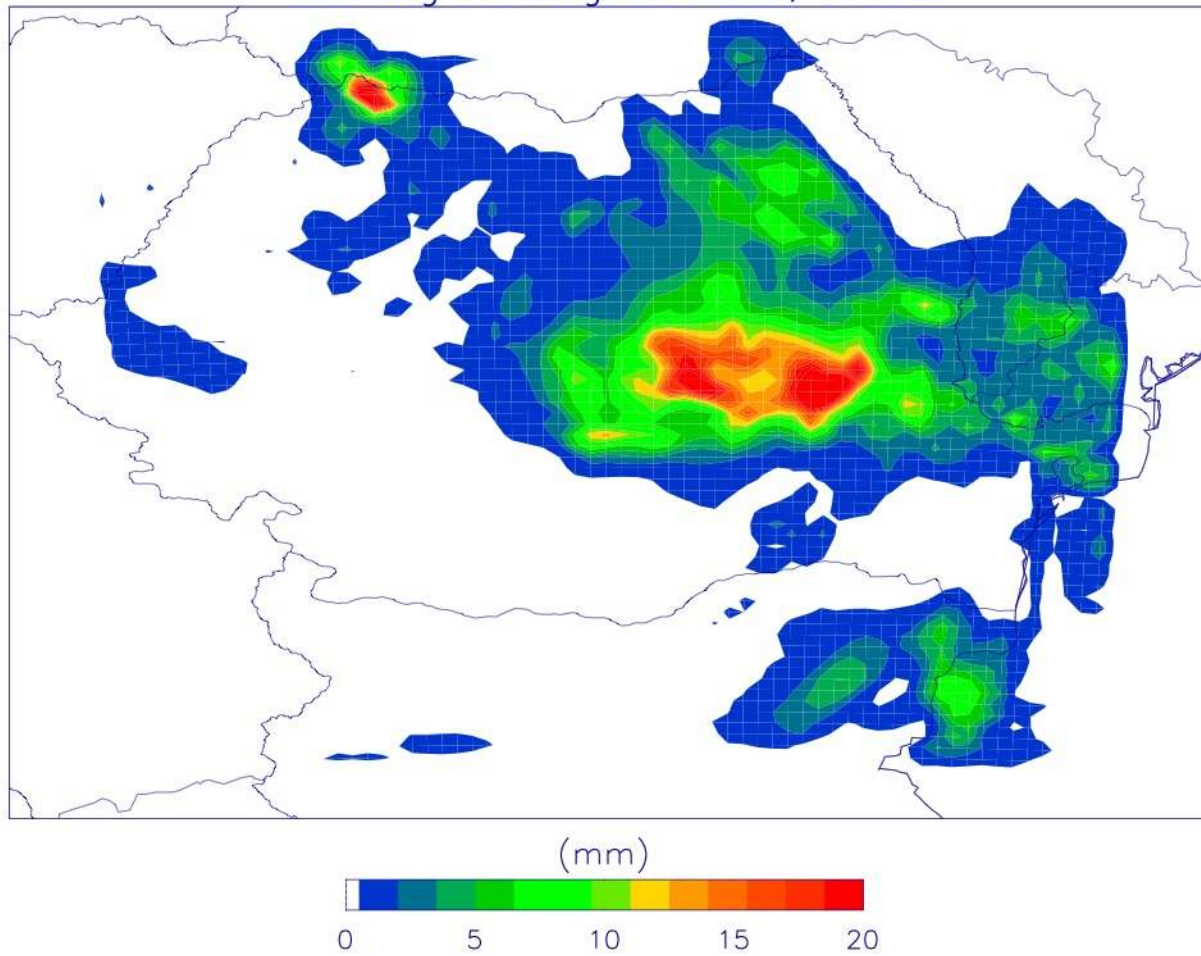


Actual radar rain accumulations for the nowcast period



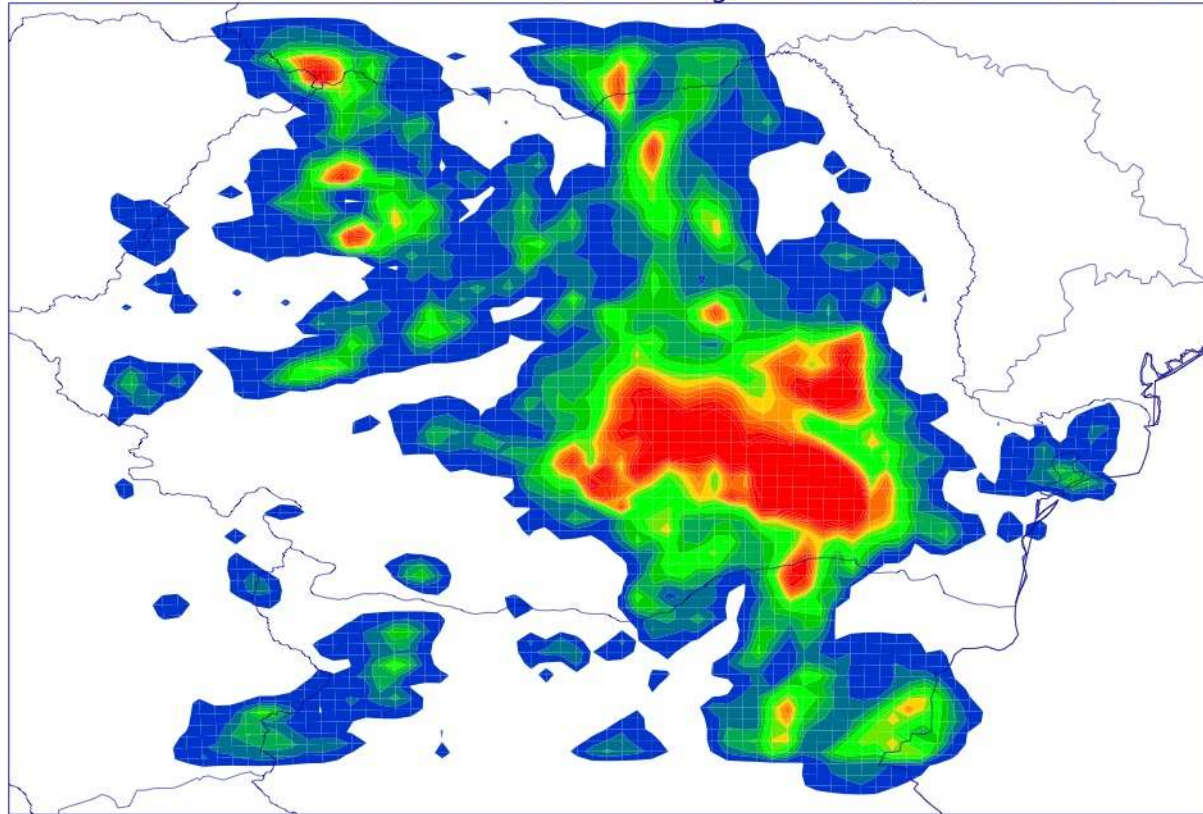
6 hour nowcast after analysis and reforecast

6 hour ensemble rain accumulation forecast
starting 23 August 2005, 21:00

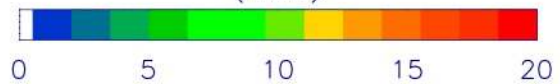


3 hour reforecast using of rain accumulation in the assimilation interval

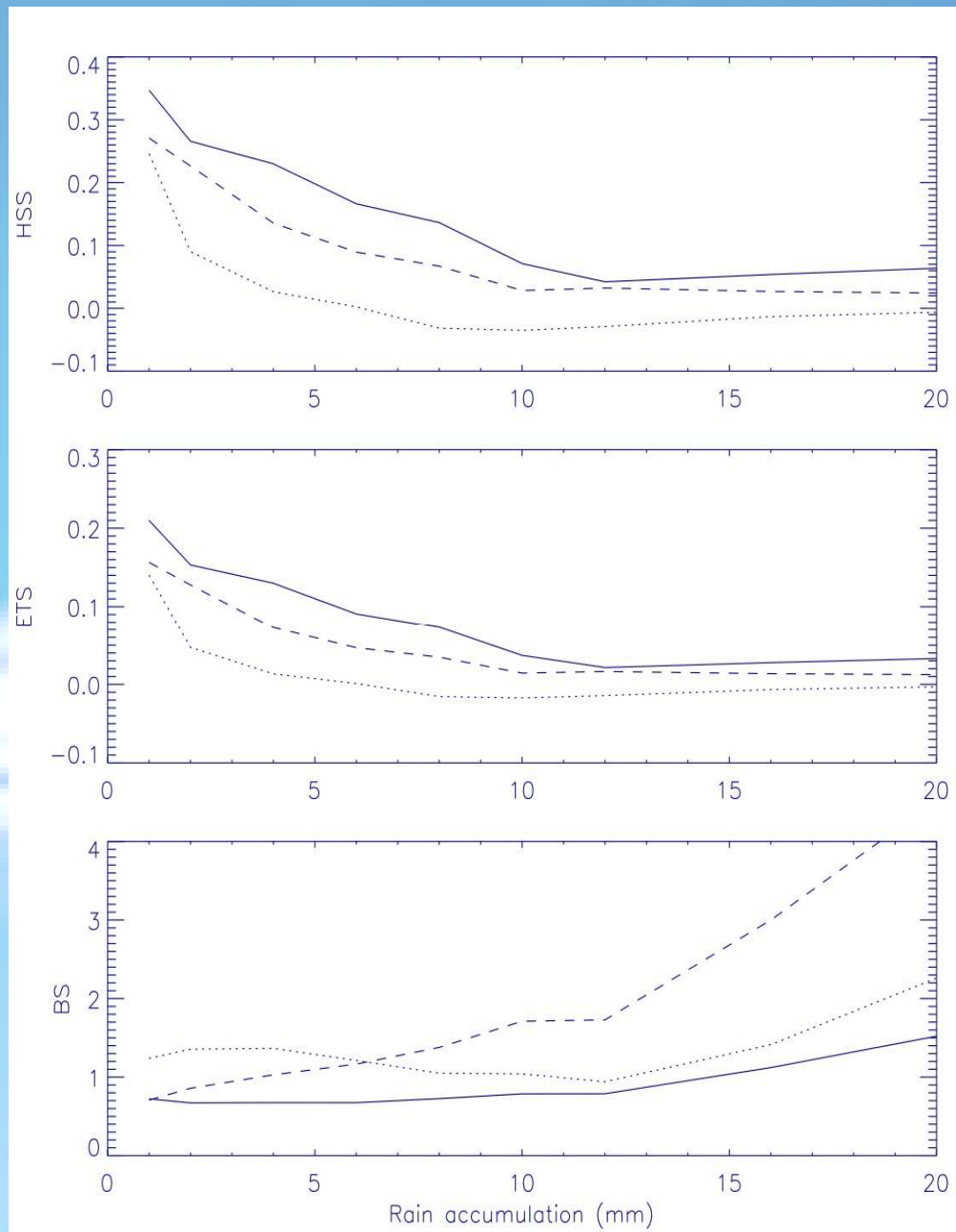
Ensemble mean reforecast, 23 August 2005, 18:00–21:00



(mm)



Scoruri statistice



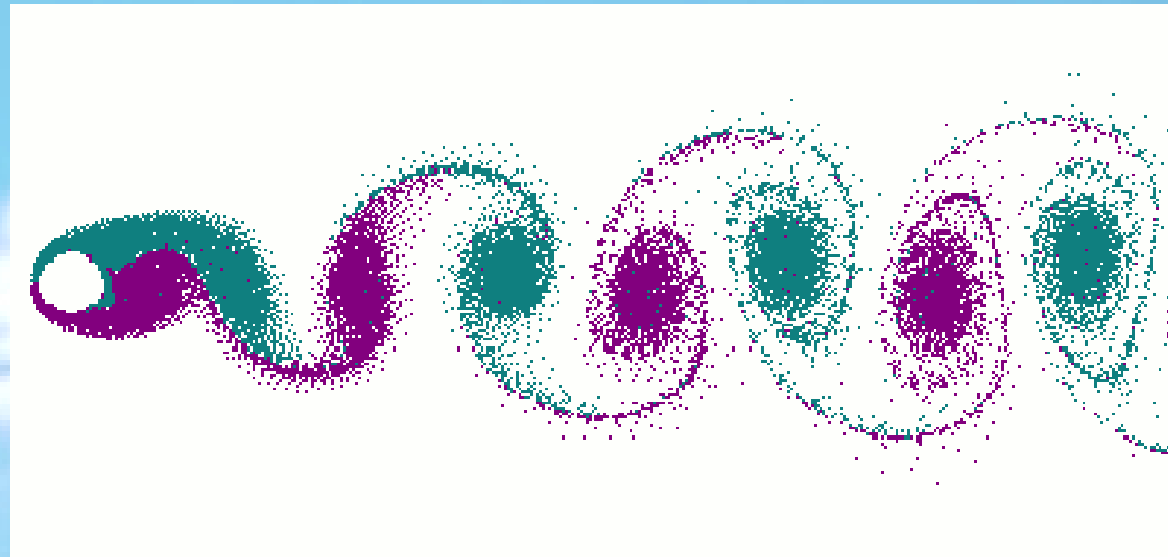
Concluzii

- Anomaliile EOFs reprezinta o modalitate eficienta de reducerea a dimensionalitatii asimilarii.
- Predictii statistice cat si predictii bazate pe reinitializare pot fi realizate in formularea prezentata.
- Asimilari succesive sunt in masura sa produca rezultate superioare.
- Studii aditionale sunt necesare pentru determinarea avantajelor potentiale oferite de utilizarea anomaliilor EOF locale.

Finantare NASA

- NASA finanteaza zeci de proiecte stiintifice
 - Estimarea incalzirii latente (NASA NEWS), a precipitatiei (NAPA PMM, NASA CloudSat) folosind datele satelitare
- NASA accepta proiecte de la Institutii non-americane, dar nu accorda finantare
 - Brazilian, Korean, German, ECMWF GPM

Aleea von Karman

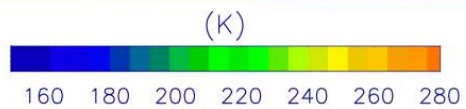
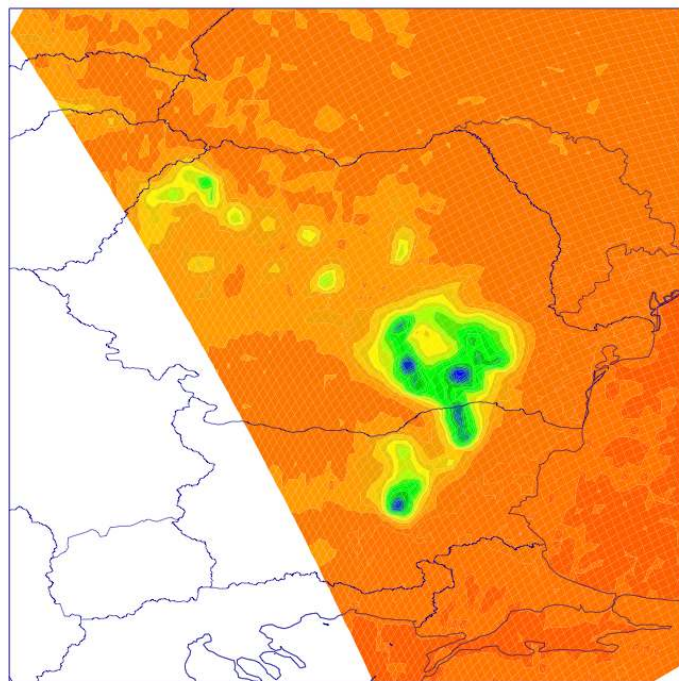


Efecte ale micro-jeturilor provocate de evaporarea norilor

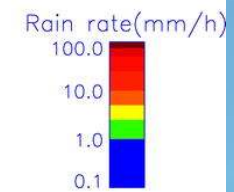
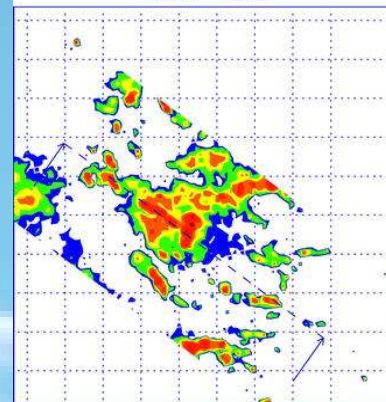


Observatii satelitare

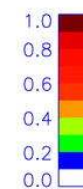
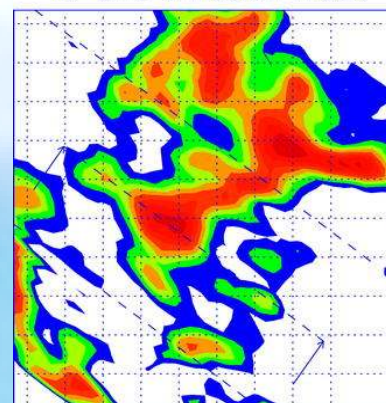
85.5-GHz PCT



Rain rate

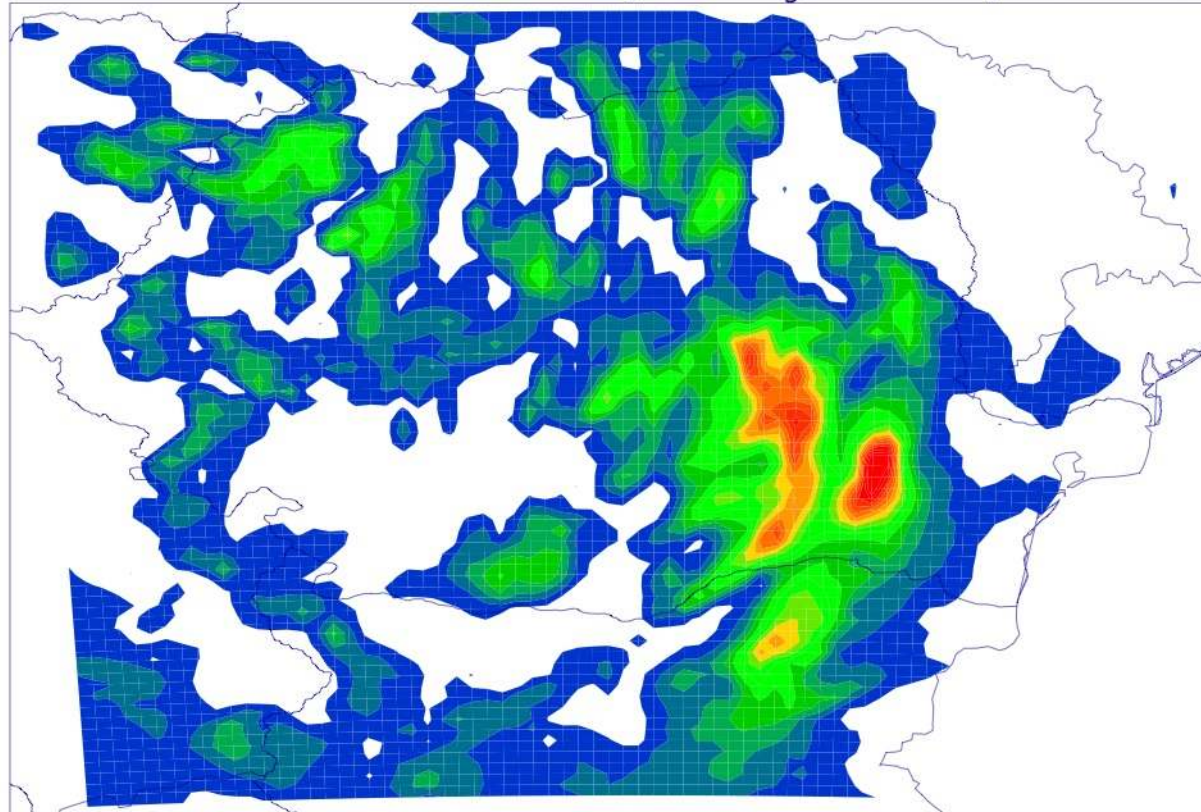


19 GHz emission index



Radar observation projection into the ensemble space

Ensemble corrected accumulation, 23 August 2005, 18:00–21:00



(mm)

