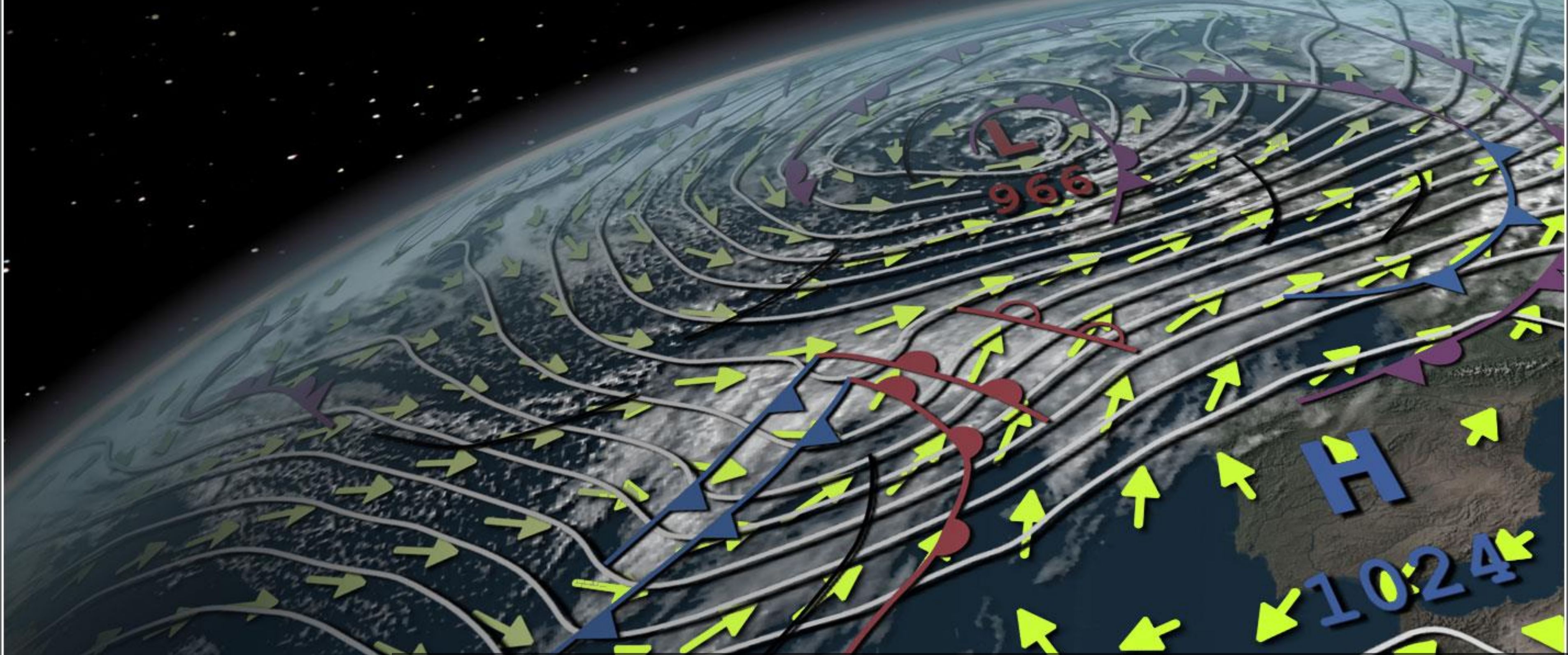
Assessing the contribution of mesoscale convective systems to model error using simulated IR imagery and numerical simulation

by Glenn Shutts



ECMWF/WWRP Workshop: Model Uncertainty, 11-15 April 2016

- use of simulated IR imagery
- 2.2 km Unified Model forecasts
  - Hazardous Weather Testbed over US
- idealized mesoscale convective event simulations
- impact of MCSs on vorticity field

Operational Stochastic Physics schemes with convection contribution

- some examples

Met Office

- perturbed convection parametrization tendencies (Buizza et al, 1999)

- perturbed parameters e.g. entrainment rate (e.g. Bowler et al, 2008)

- Stochastic Convective Vorticity scheme (Gray, 2001)

- Stochastic Kinetic Energy Backscatter (through convective dissipation rate) (Shutts,2005)

- Plant-Craig Stochastic Convection Parametrization scheme (2014)

- Stochastic Convective Backscatter (Shutts,2015)

Horizontal divergence forcing linked to parametrized convective mass flux

Looking for the cause of random model error

- simulated infra-red imagery a useful tool ?

- Met Office ‘Tigger’ web pages provide daily one-to-one comparison for global, UKV and EURO4 UM forecasts

- comparison of simulated vs actual imagery over the US particularly interesting in respect of mesoscale convective systems

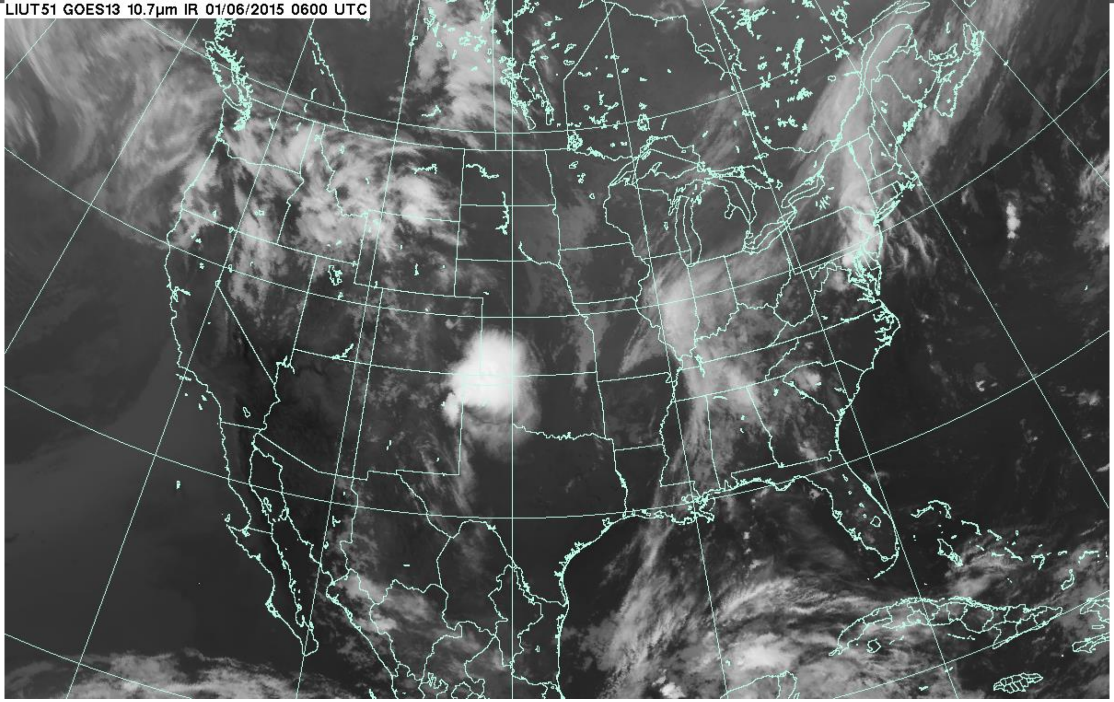
- general impression – simulated IR over the Atlantic/Europe regions surprisingly realistic although...

    - cloud ‘texture’ not captured

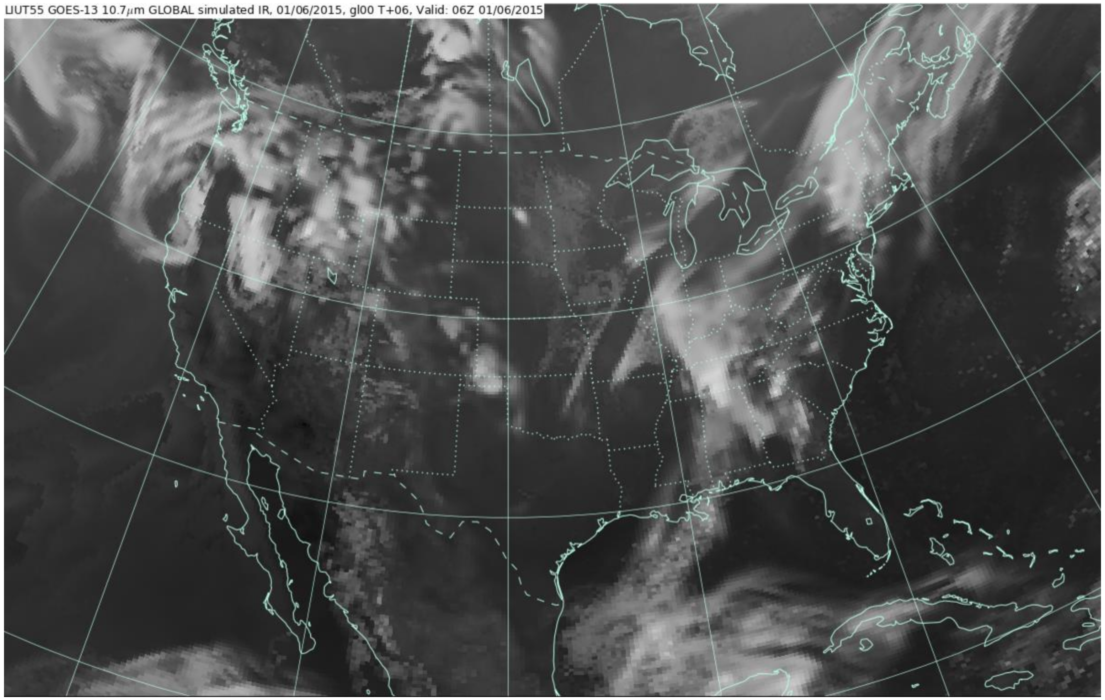
    - big convective events often mishandled

Met Office

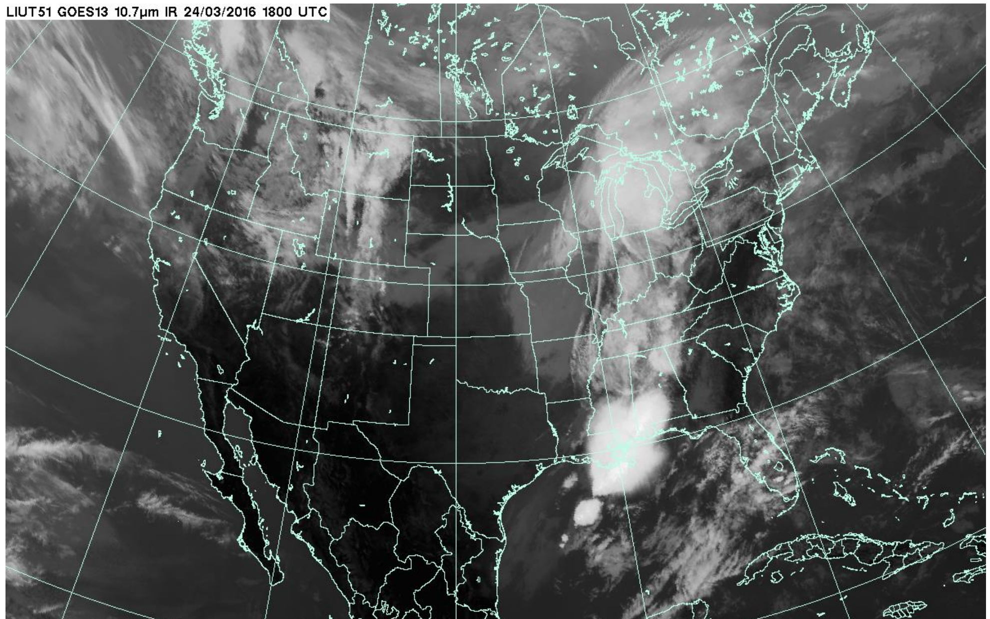
IR from space
June 1st 2015



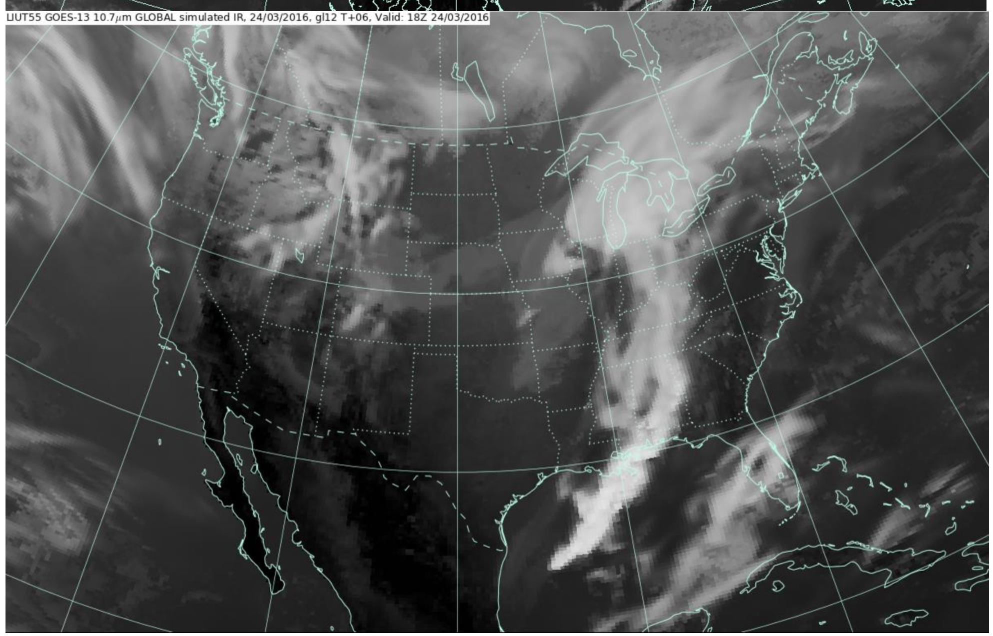
simulated IR
from global
UM model
forecast
T+6 hrs



Infra-red radiance 10.7 micron
March 24 2016 18Z

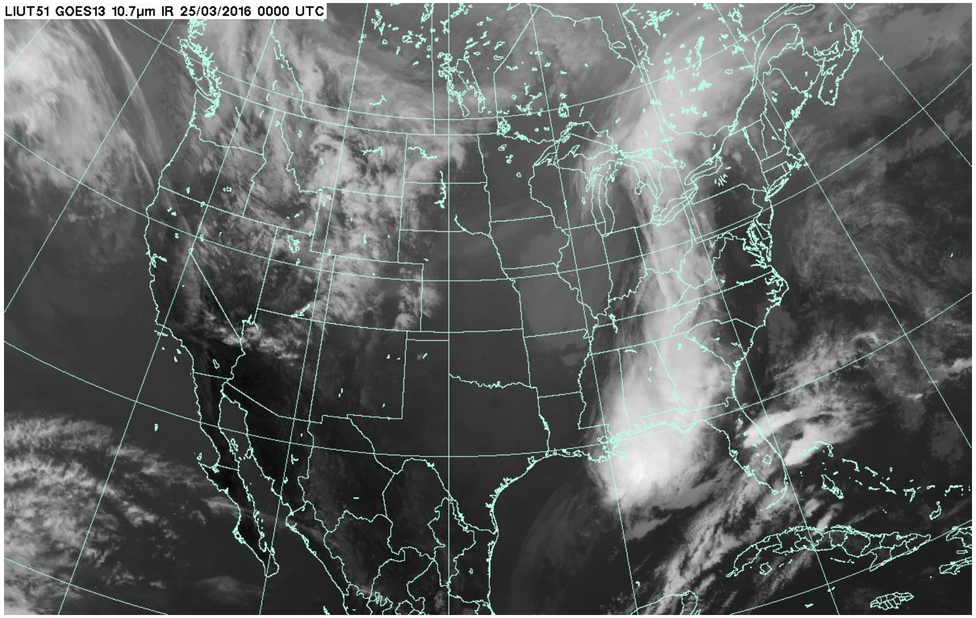


Actual IR

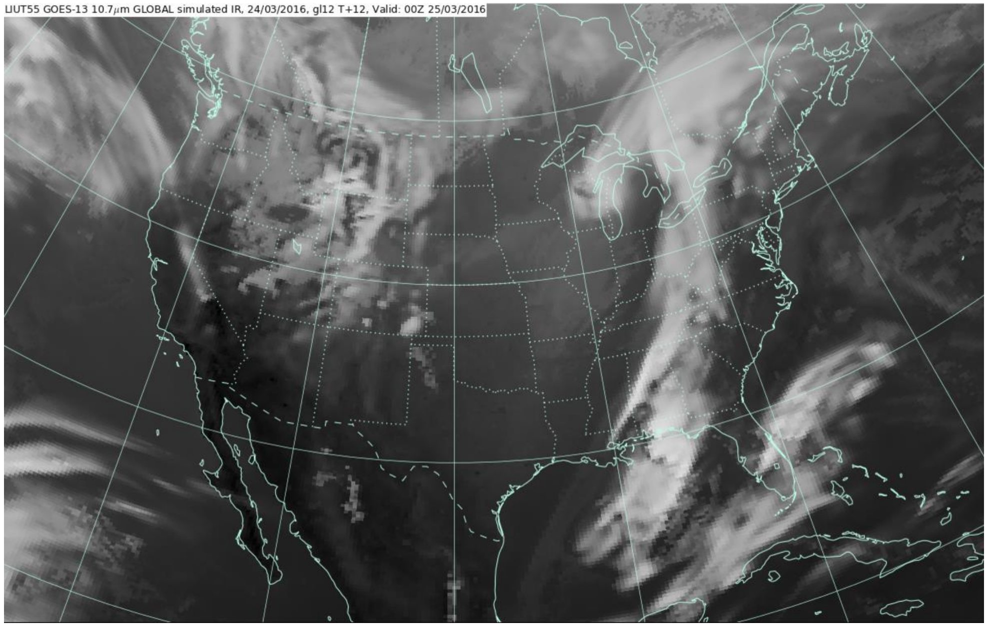


simulated
T+6 hr fc
Global UM

Infra-red radiance 10.7 micron
March 25 2016 00Z



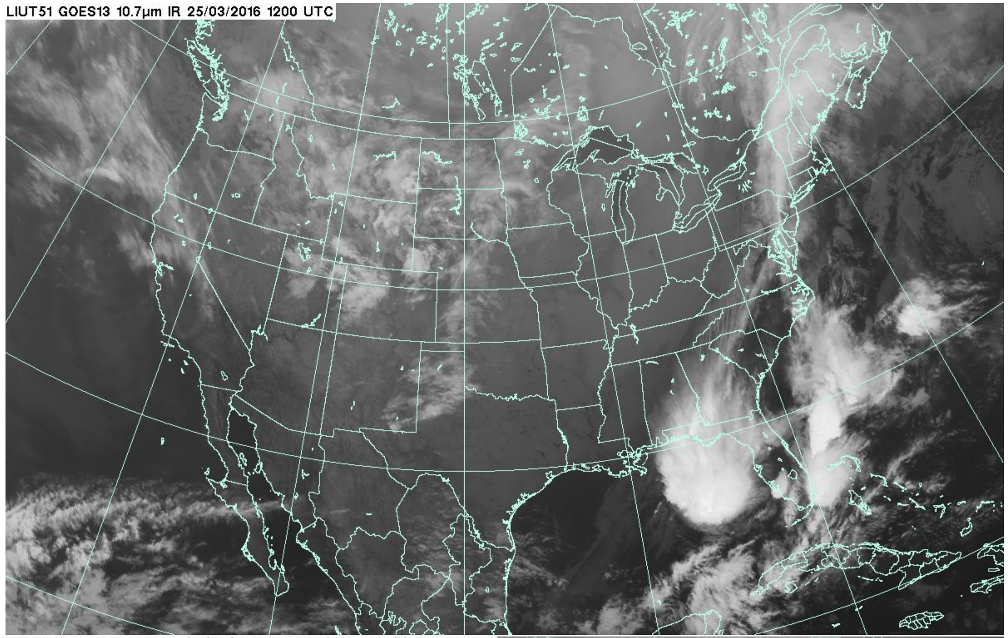
Actual IR



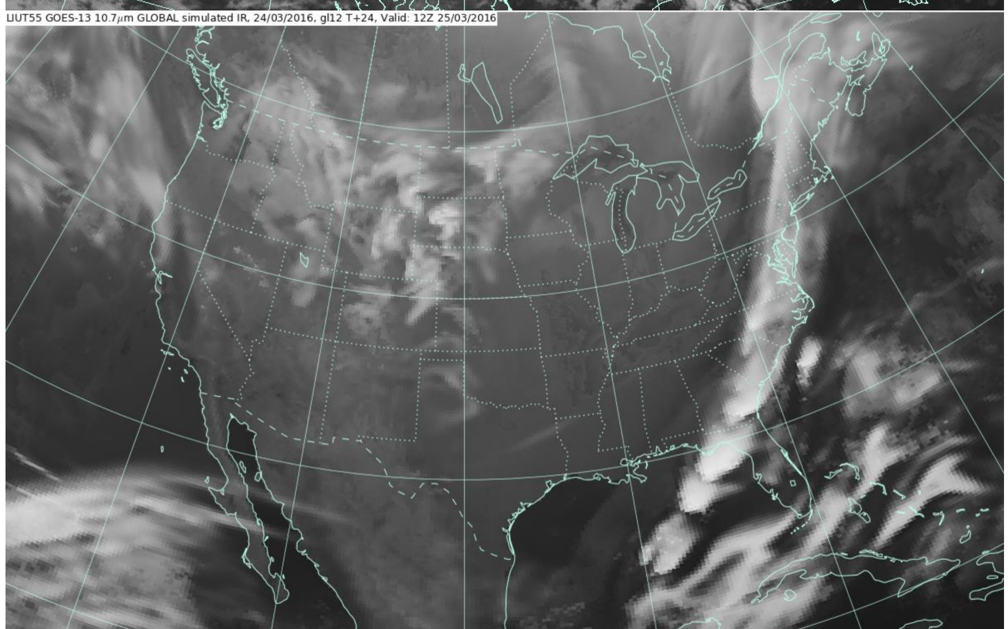
simulated
T+12 hr fc
Global UM

Met Office

Infra-red radiance 10.7 micron March 25 2016 12Z



Actual IR

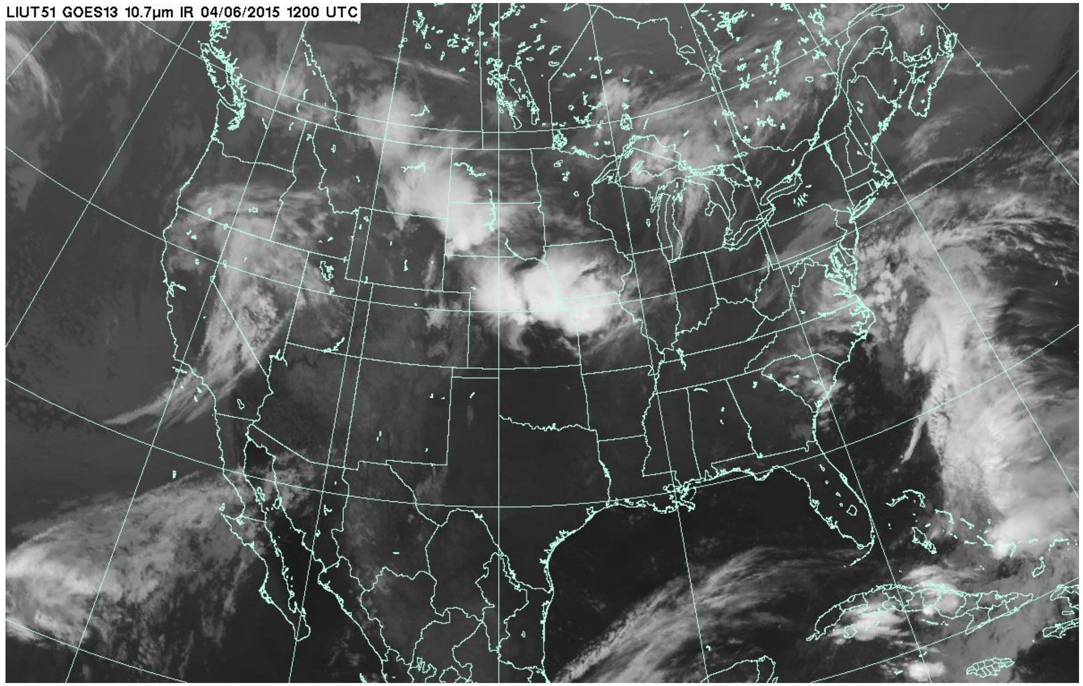


simulated T+24 hr fc Global UM

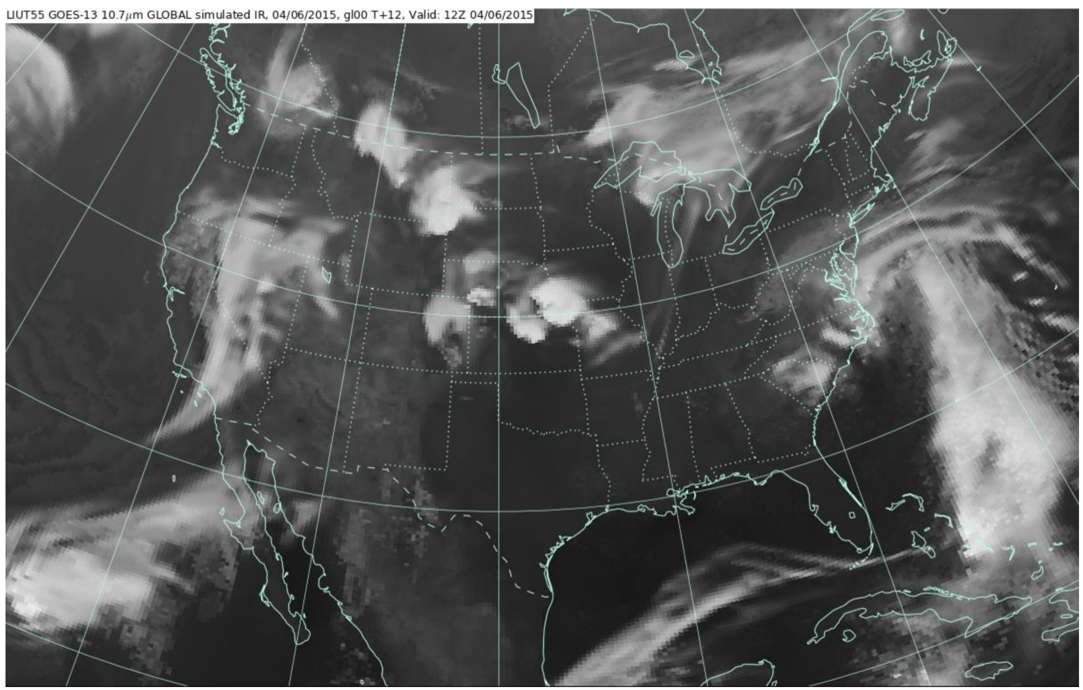
Met Office

Global model

June 4th 2015
12Z



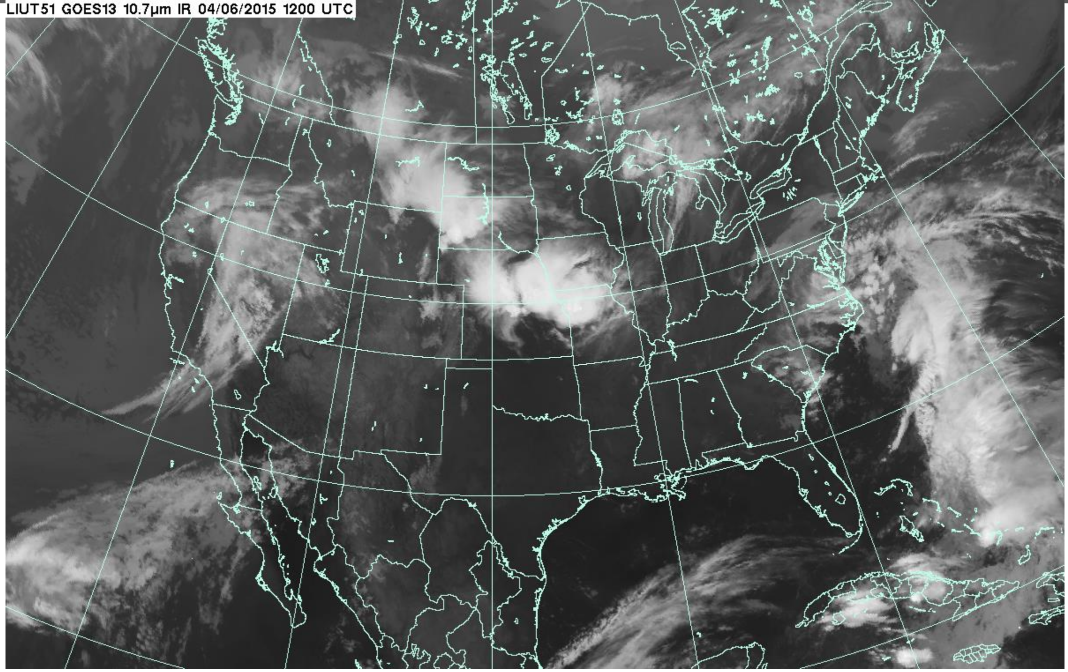
actual



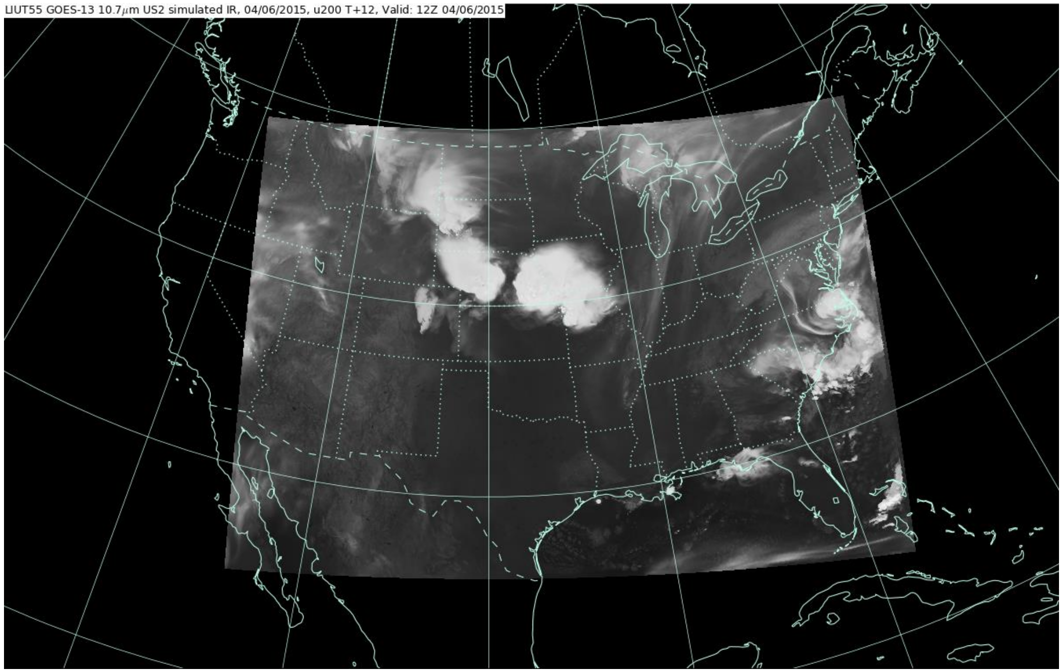
Simulated
T+12 hrs

UM at 2.2 km

explicit convection



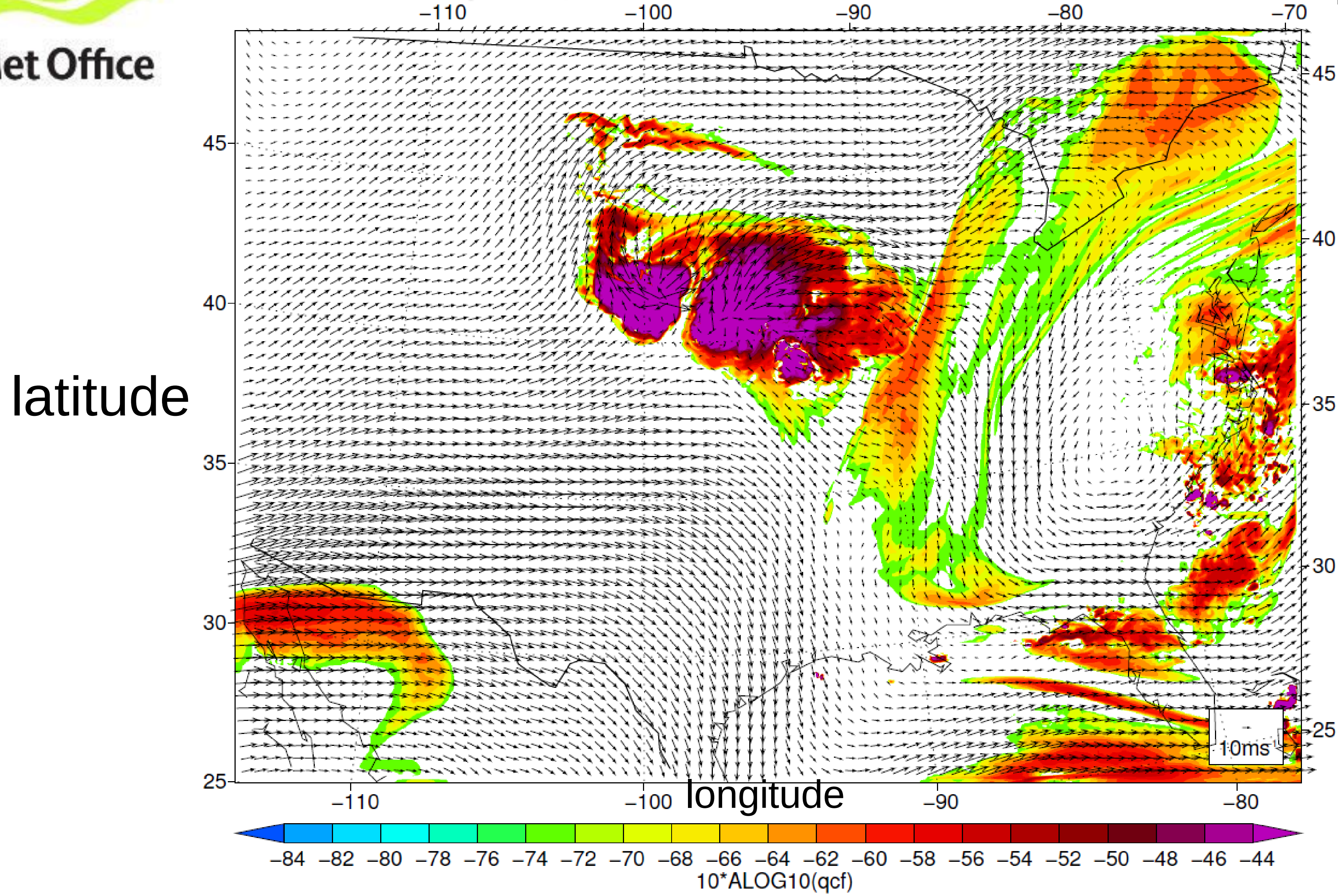
actual



UM 2.2 km
T+12 hrs

ice mixing ratio in 2.2 km Unified Model forecasts

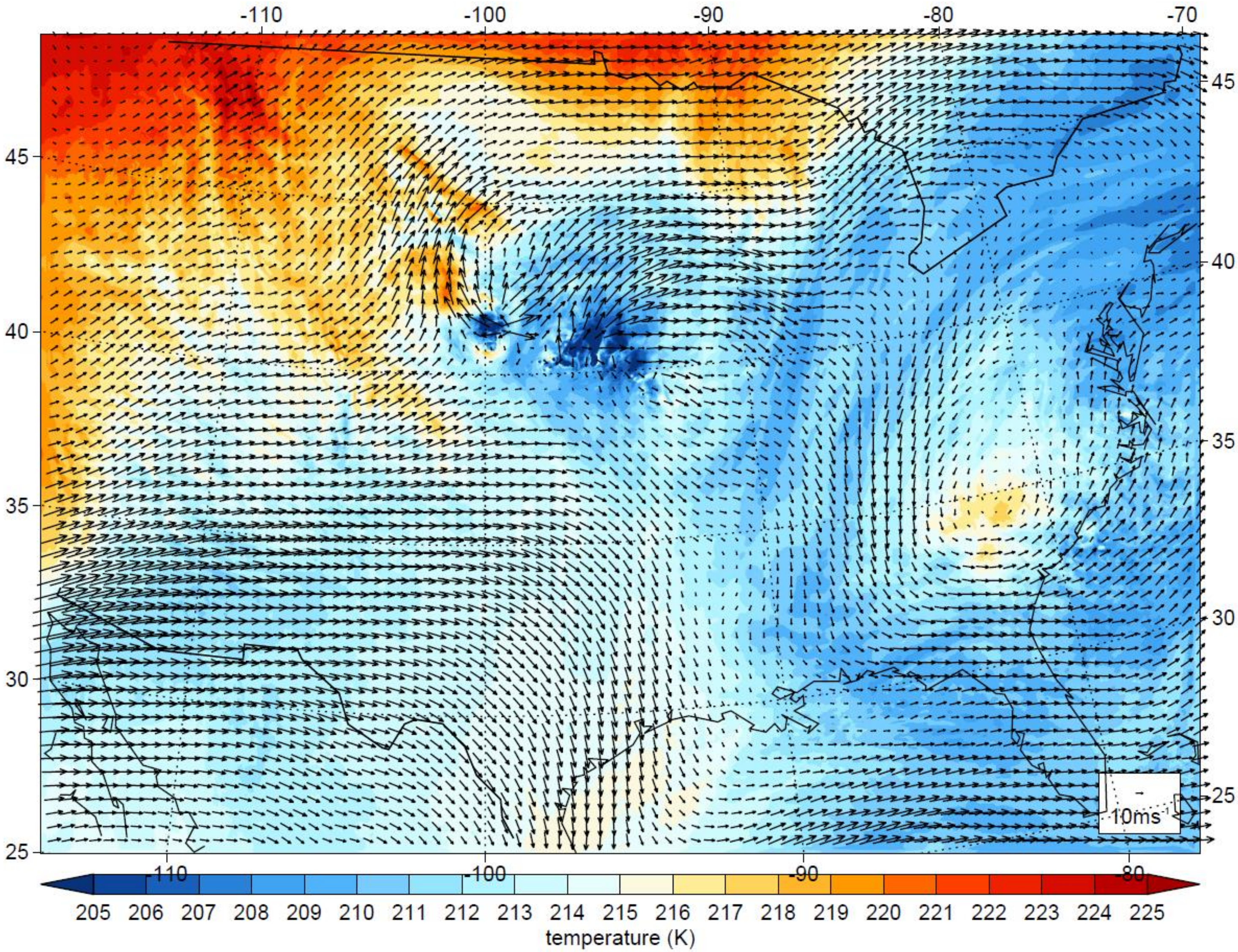
($\log_{10}$(qcf) at a height of 11 km)



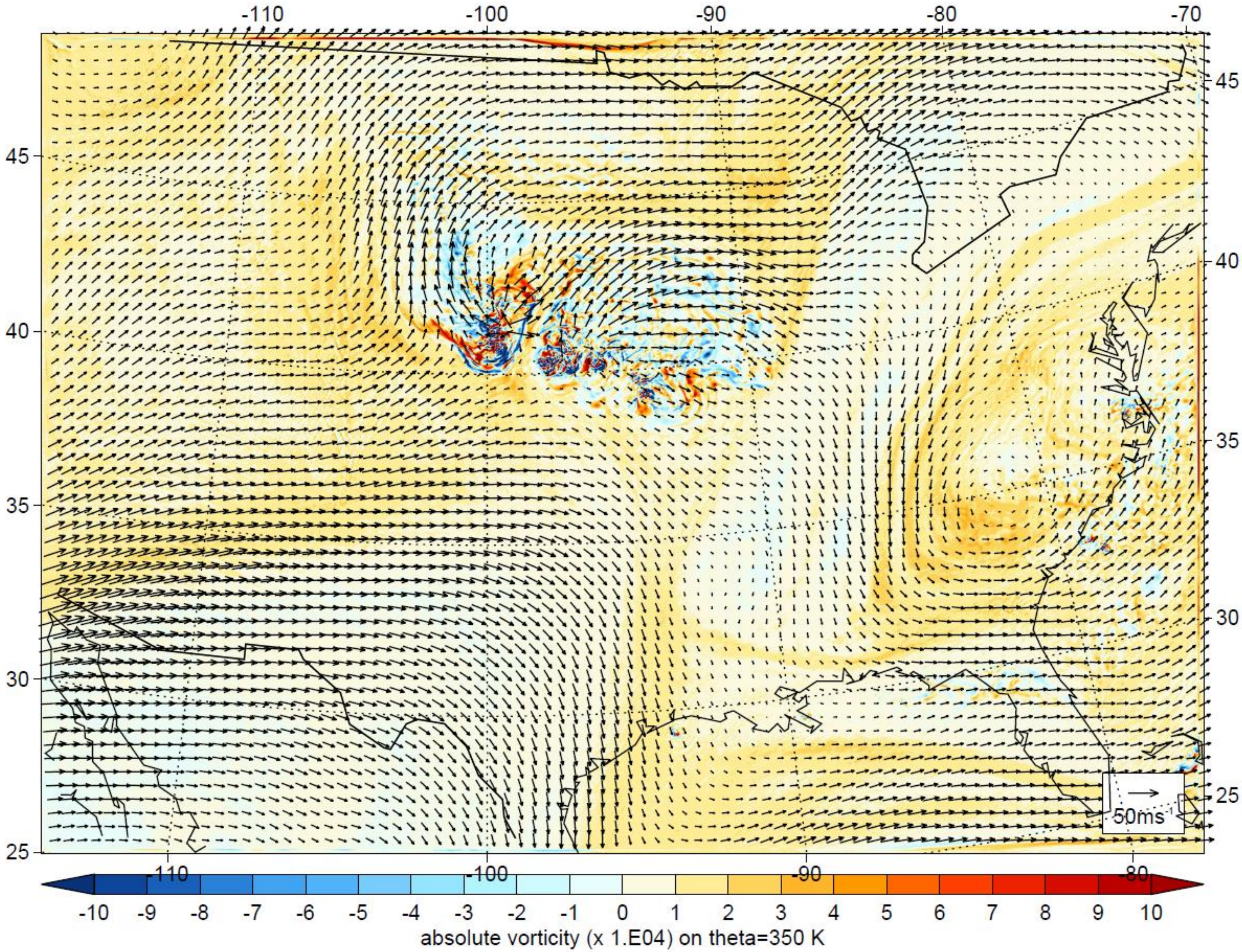
Temperature (T+12 hrs, ~11 km)

longitude

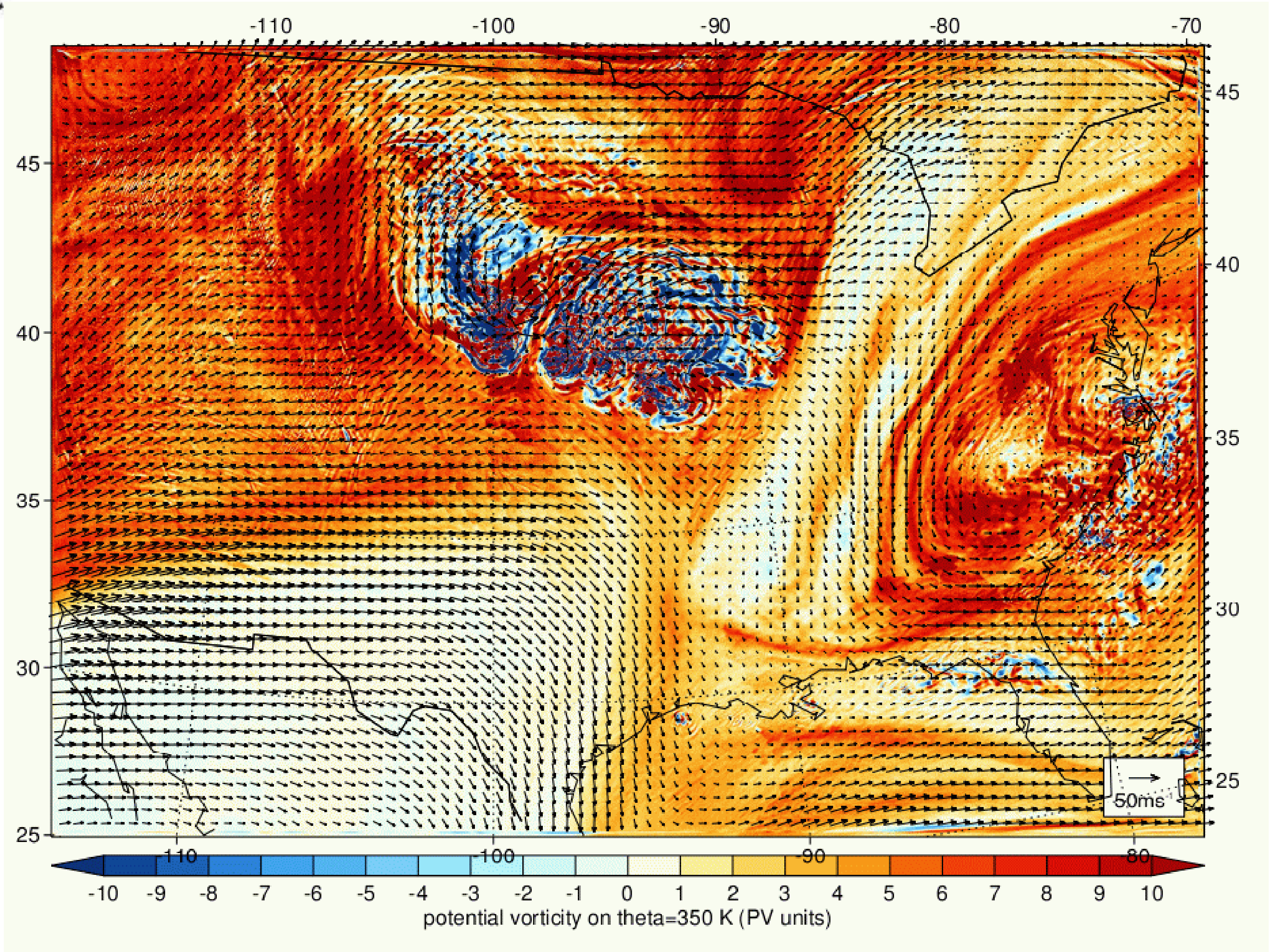
latitude



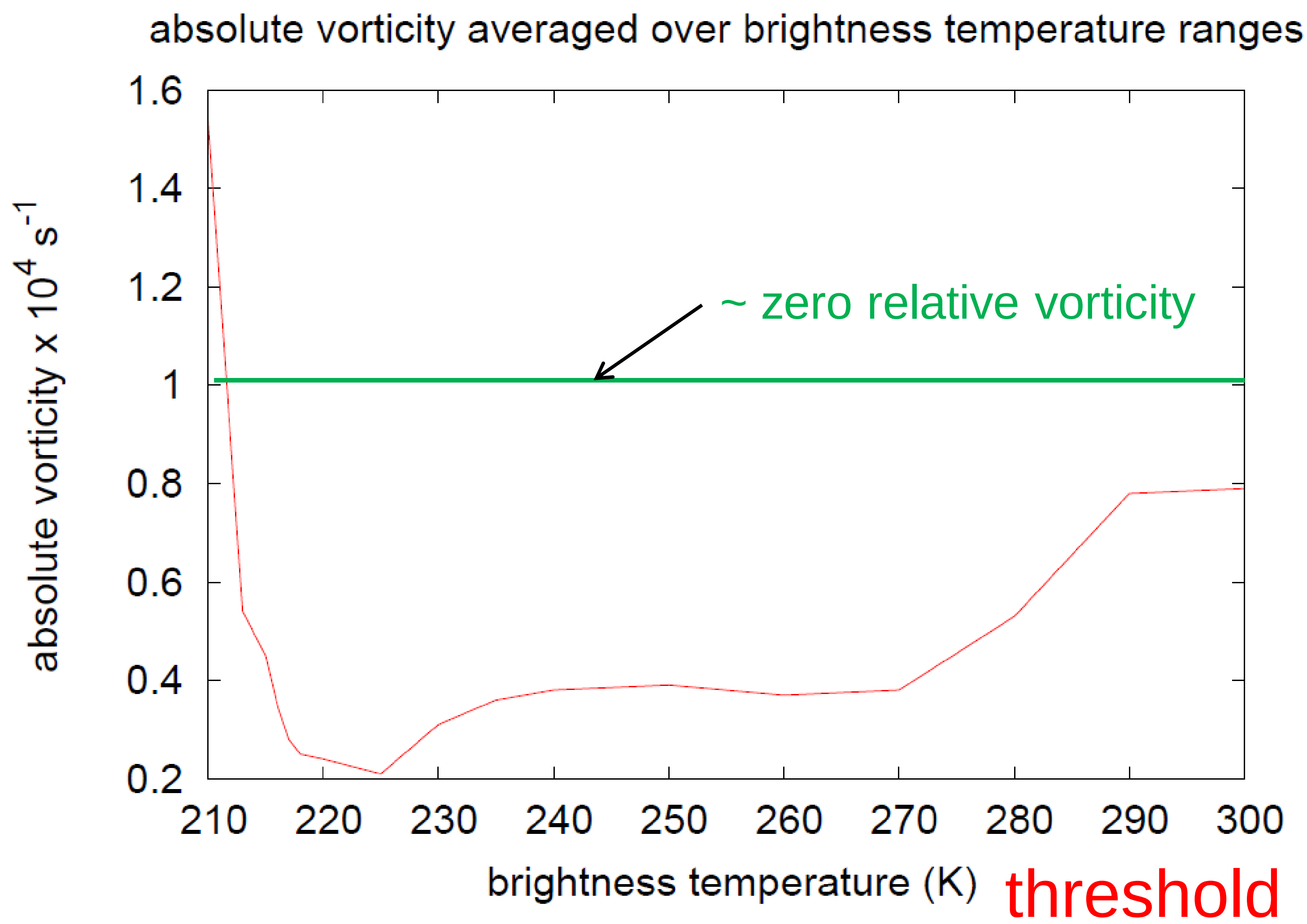
Absolute vorticity and wind vectors on the 350 K theta surface



PV on the 350 K theta surface and horizontal winds



Absolute vorticity averaged over regions where the simulated brightness temperature is < a chosen threshold

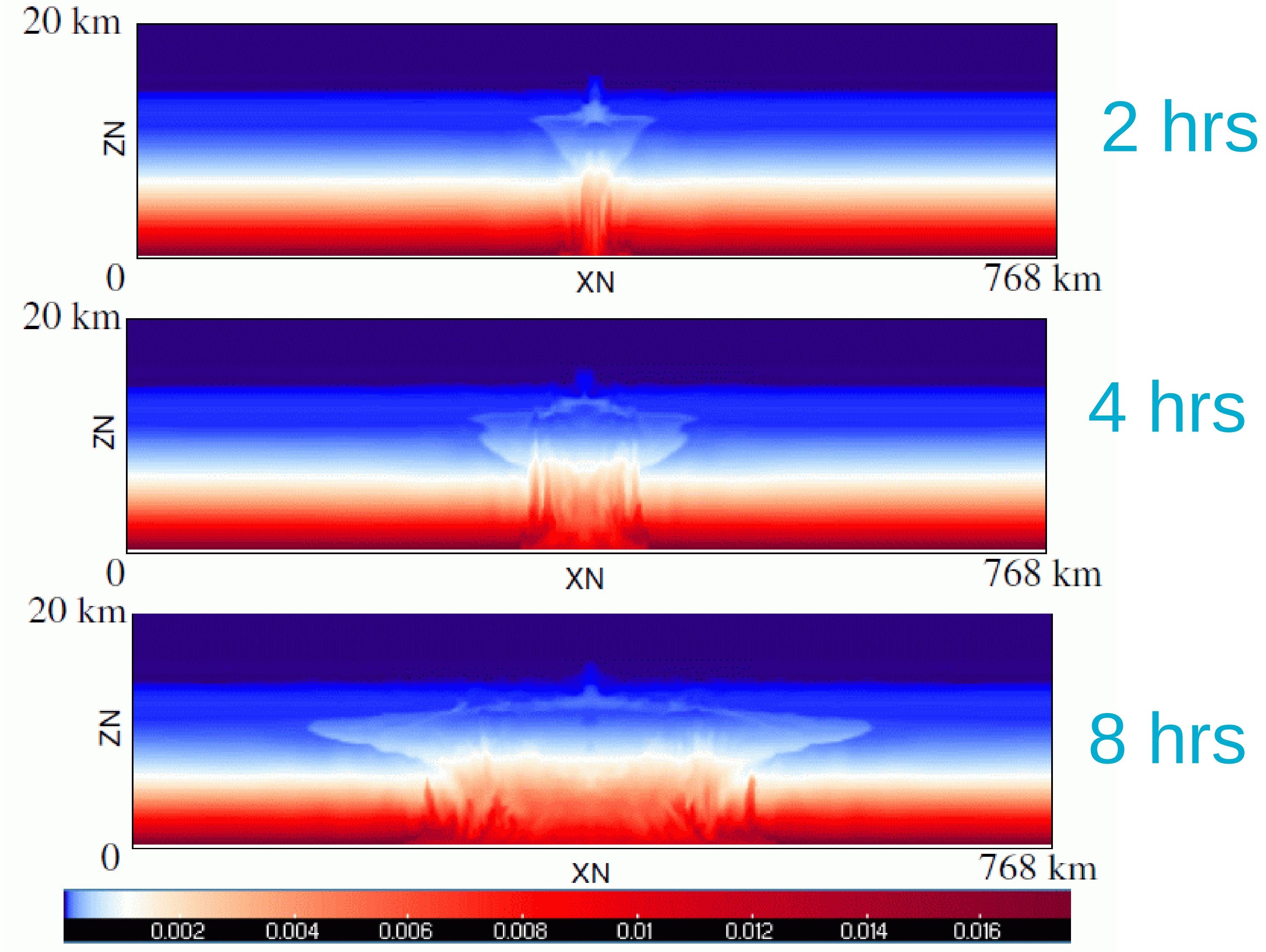


Large Eddy Model simulation

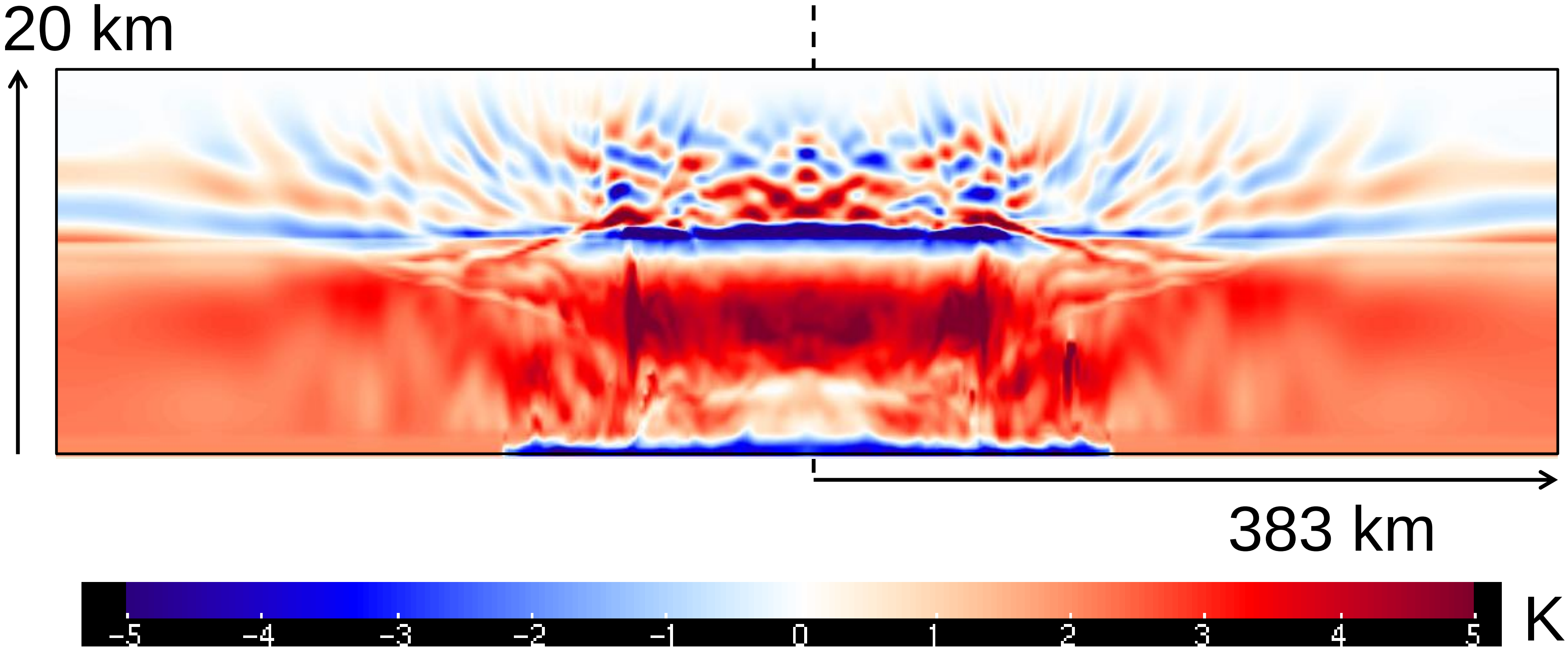
- domain 384x384x100 points dx=dy=2 km
- run without **any** explicit diffusion
- advection by **ULTIMATE** on all variables
- ‘full’ ice microphysics
- run from rest for 12 hours
- initialize with a circularly-symmetric Gaussian warm spot in lowest kilometre

Coriolis parameter = 10^{-4} s^{-1} (mid-latitude value)

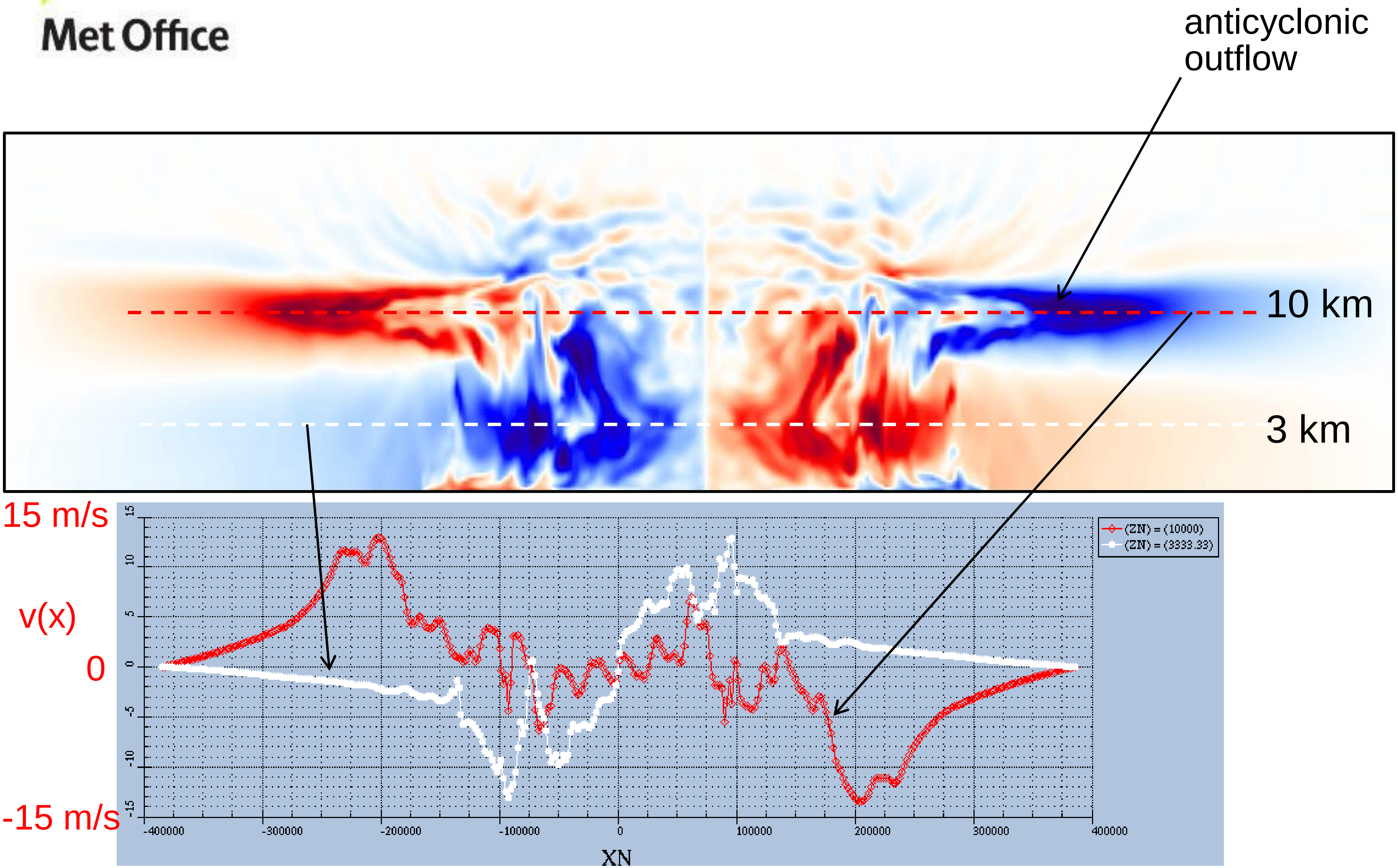
Vertical section of water vapour mixing ratio through MCS plume at 2, 4 and 8 hrs



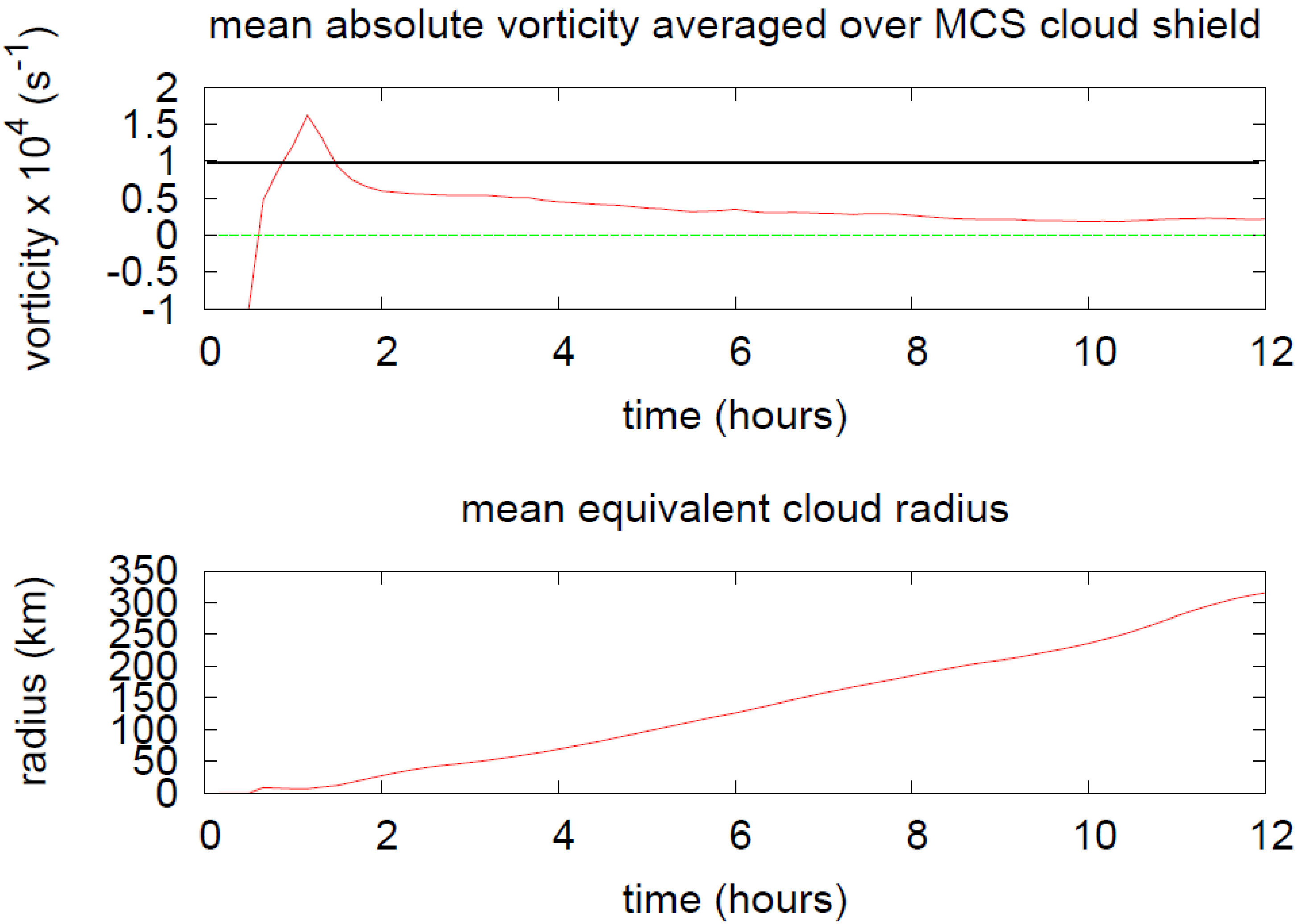
Potential temperature perturbation yz-section at T+8 hrs



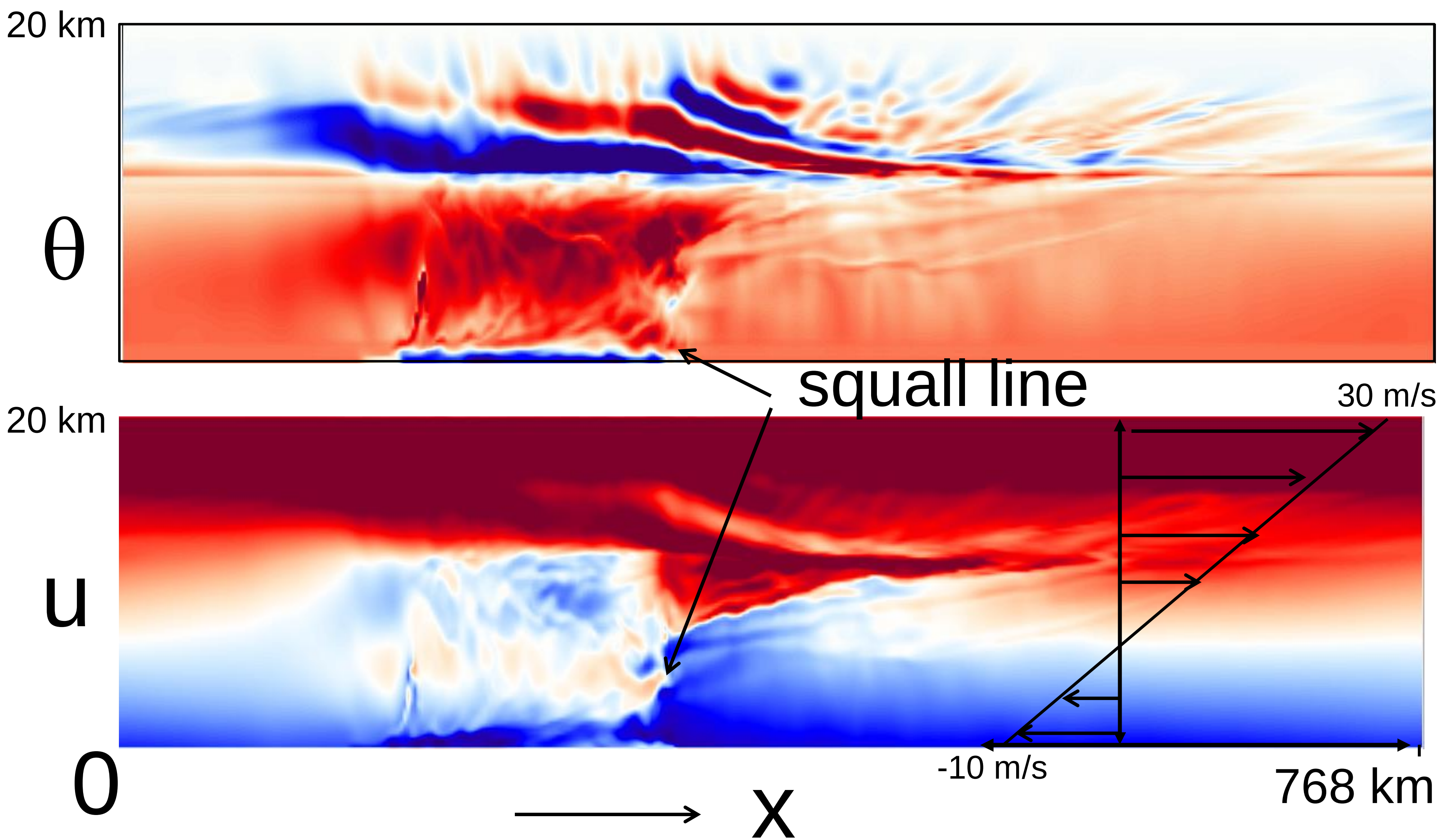
v wind component (+ve into picture)



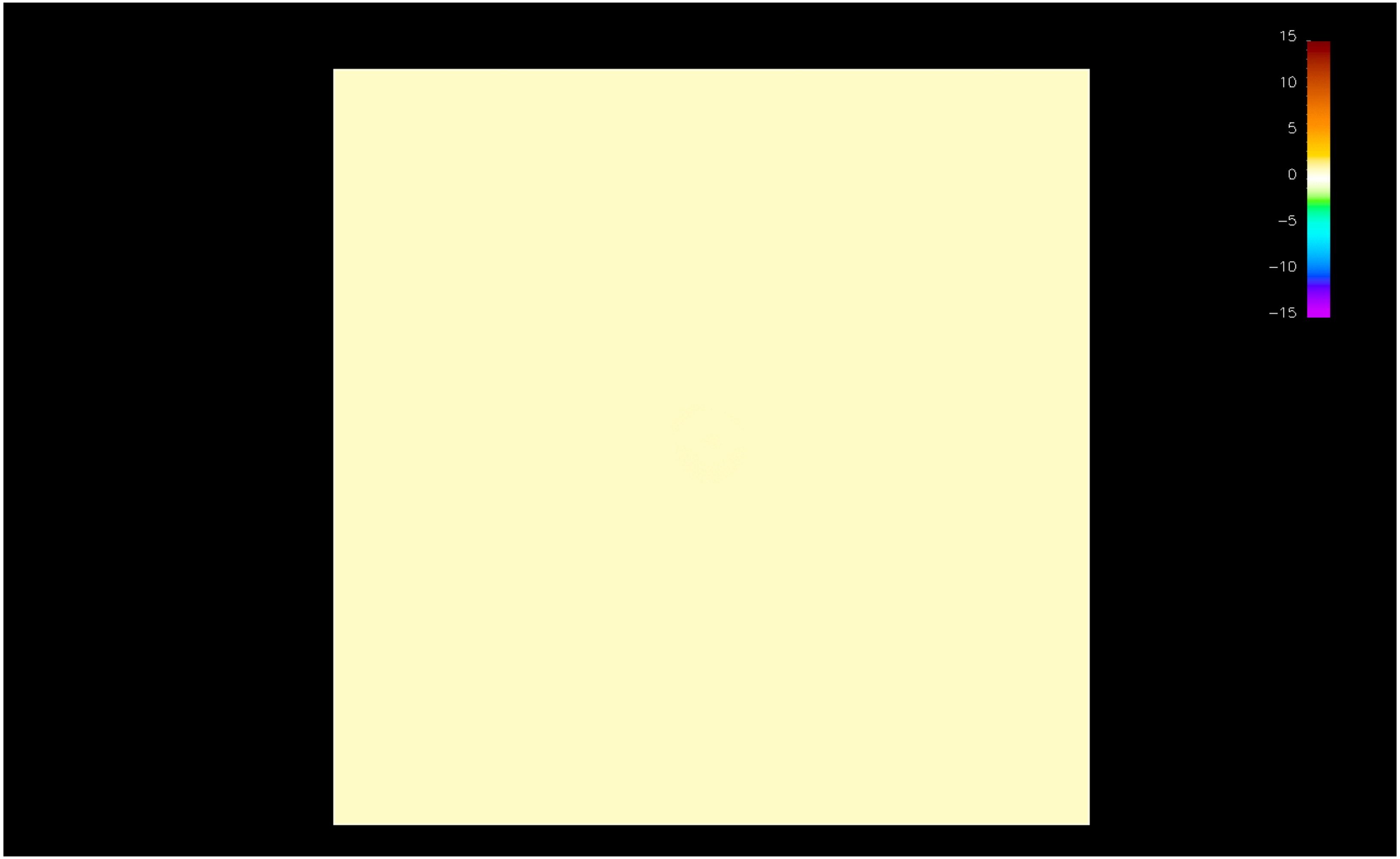
Absolute vorticity averaged over the upper cloud shield



MCS with vertical wind shear



Absolute vorticity evolution in cloud shield



Relate to model uncertainty and stochastic physics

• *associate* satellite brightness temperature in MCSs with characteristic vorticity and divergence patterns

• quantify IR radiance ‘error’ of global UM forecasts in MCS situations

• quantify model error in divergence/vorticity forcing

Questions and comments ?