# Unresolved Processes in Weather and Climate Models: Lessons from the Laboratory

Paul Williams

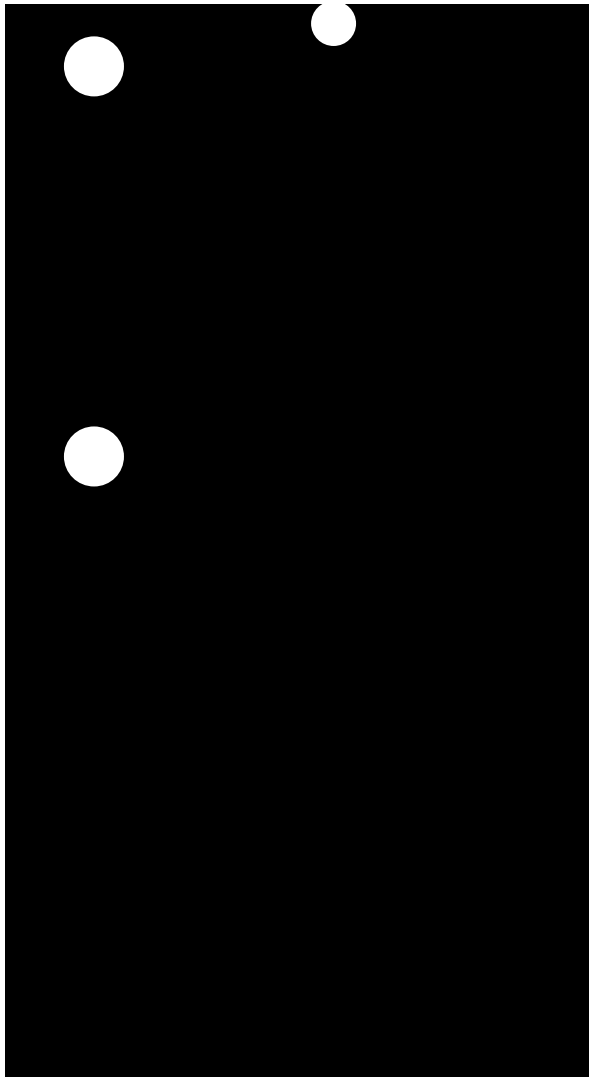
Department of Meteorology, University of Reading, UK

- Problems:
  - the performance of weather and climate models is limited by subgrid-scale processes
  - the approximate treatment (i.e. parameterization) of subgrid-scale processes is not strongly constrained by theory or observations

- This poster argues that:
  - useful insights may be gained from laboratory experiments on rotating fluids
  - e.g., the study of laboratory gravity waves can be used to guide gravity-wave drag parameterizations in the atmosphere; to estimate mixing rates in the deep ocean; and to motivate stochastic parameterization

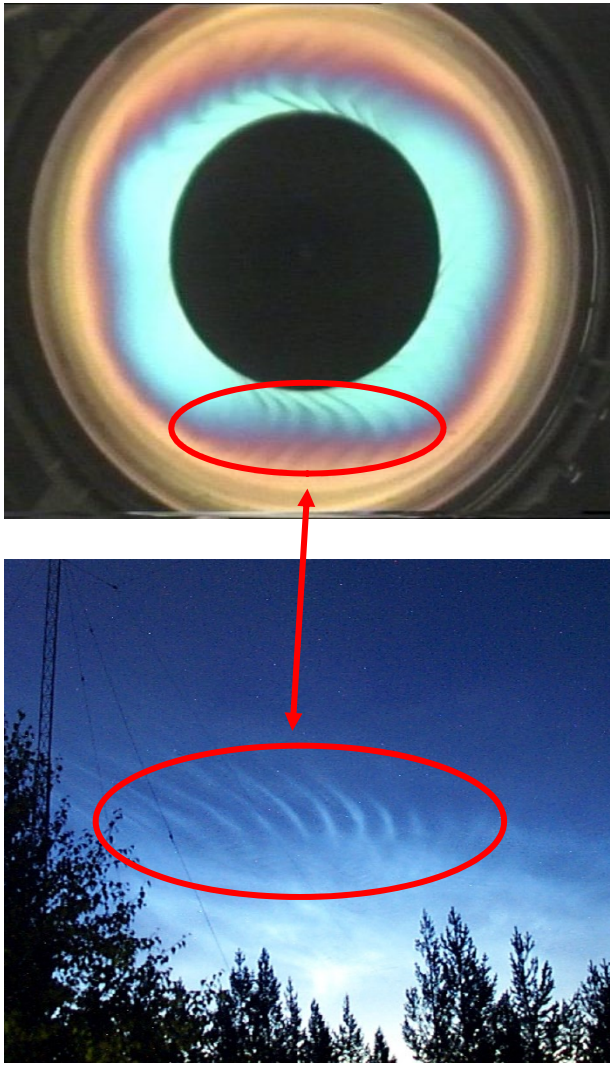
# 1. A laboratory analogue for atmospheric and oceanic fluid flow

rotating annulus:



Read et al. (1998)

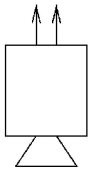
rotating planet:



Williams et al. (2003)

Dalin et al. (2004)

# 2. The laboratory experiment

video camera

125.0 mm

62.5 mm

super-rotating lid

slightly different densities

water

limonene

CFC113

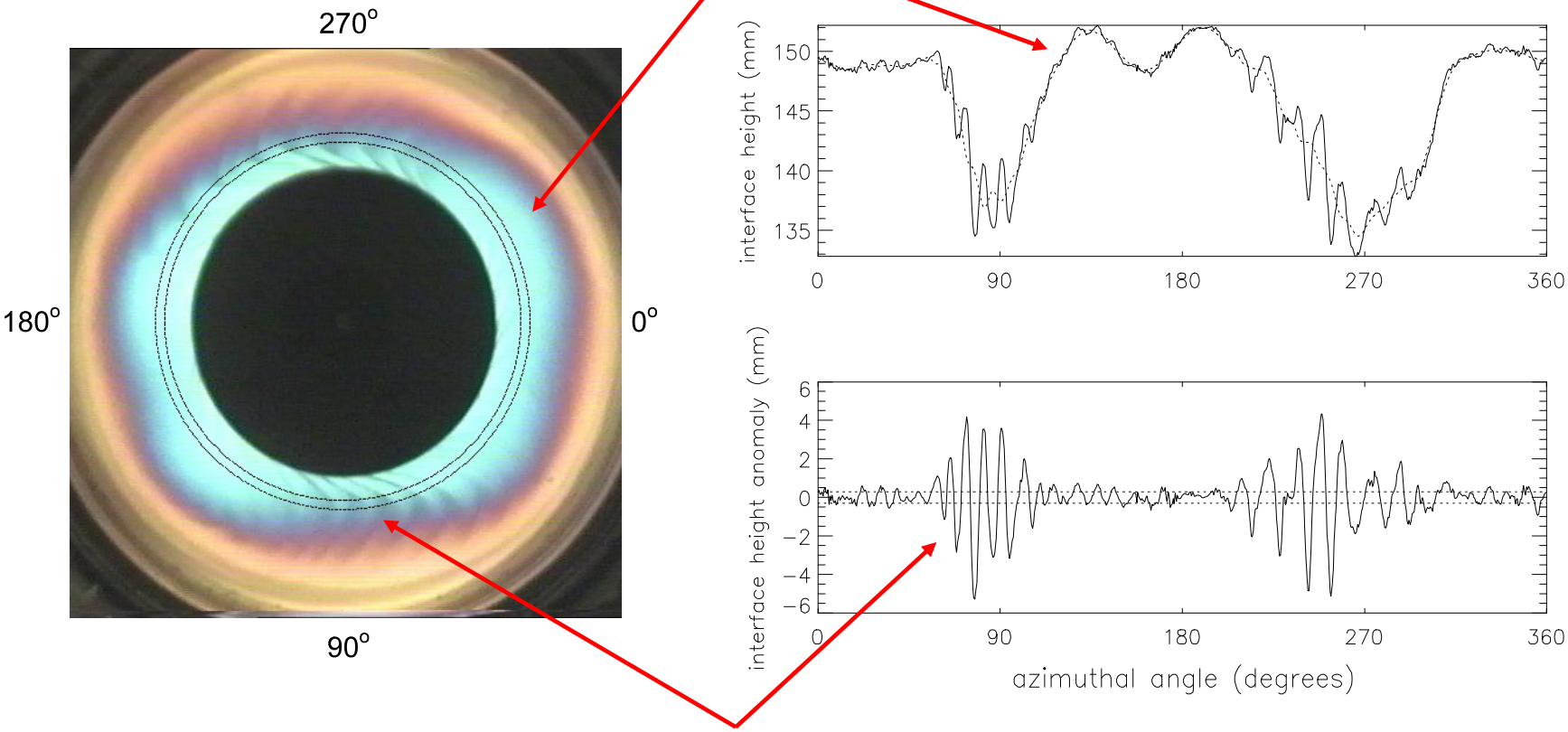
250.0 mm

rotating turntable

lamp

# 3. Application to deep ocean mixing

balanced baroclinic eddies

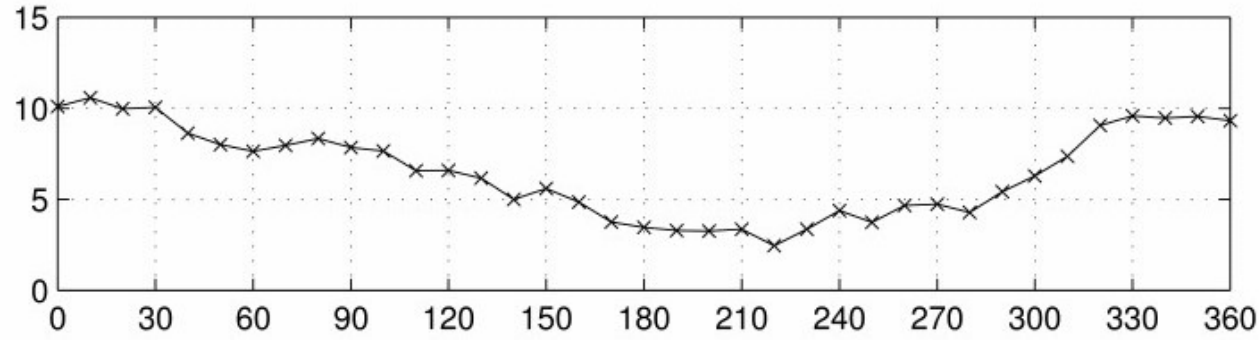



internal inertia-gravity waves (IGWs)
generated by loss of balance…

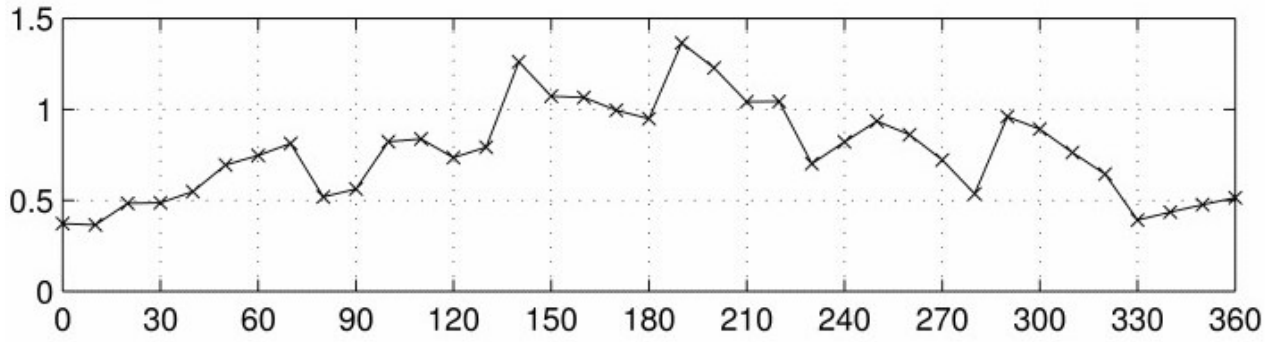
Williams et al. (2008)

# 4. Application to deep ocean mixing

eddy amplitude




internal wave amplitude

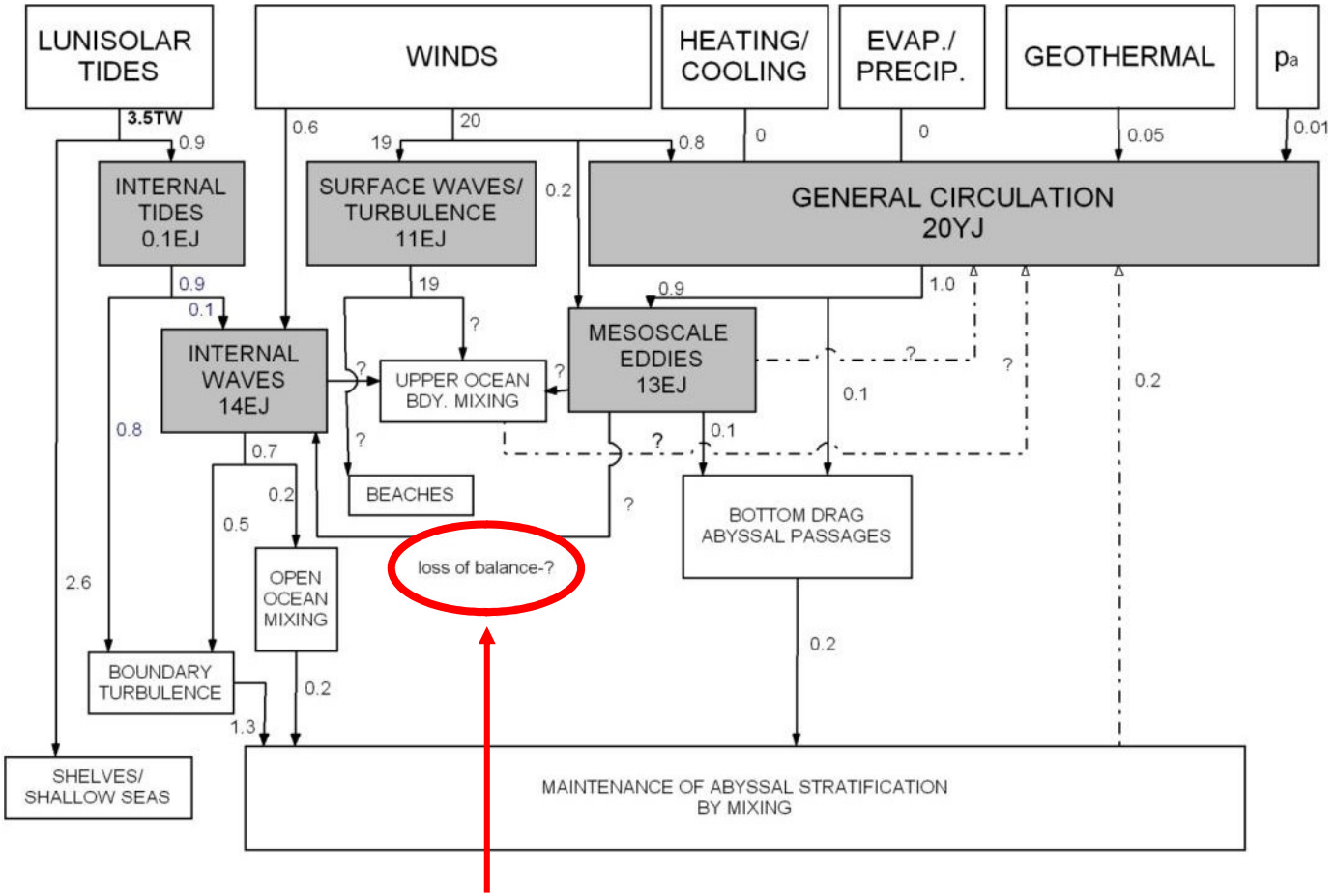



~ time

→ eddies leak ~1% of their energy into the internal waves per turntable rotation period

Williams et al. (2008)

# 5. Application to deep ocean mixing

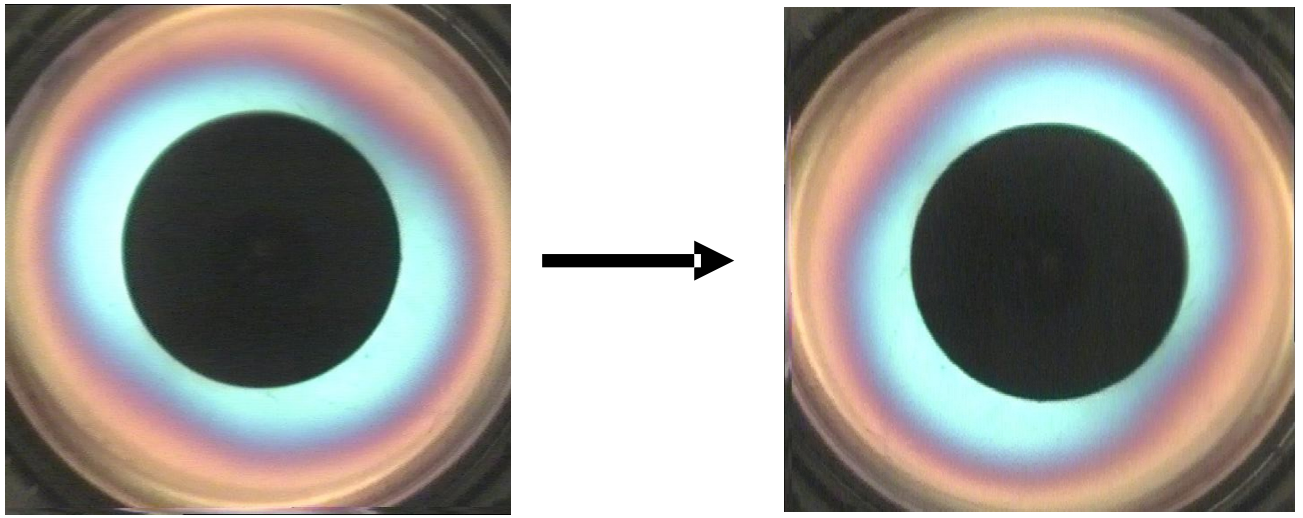



**“of unknown importance”**
**– lab suggests 1.5 TW !**

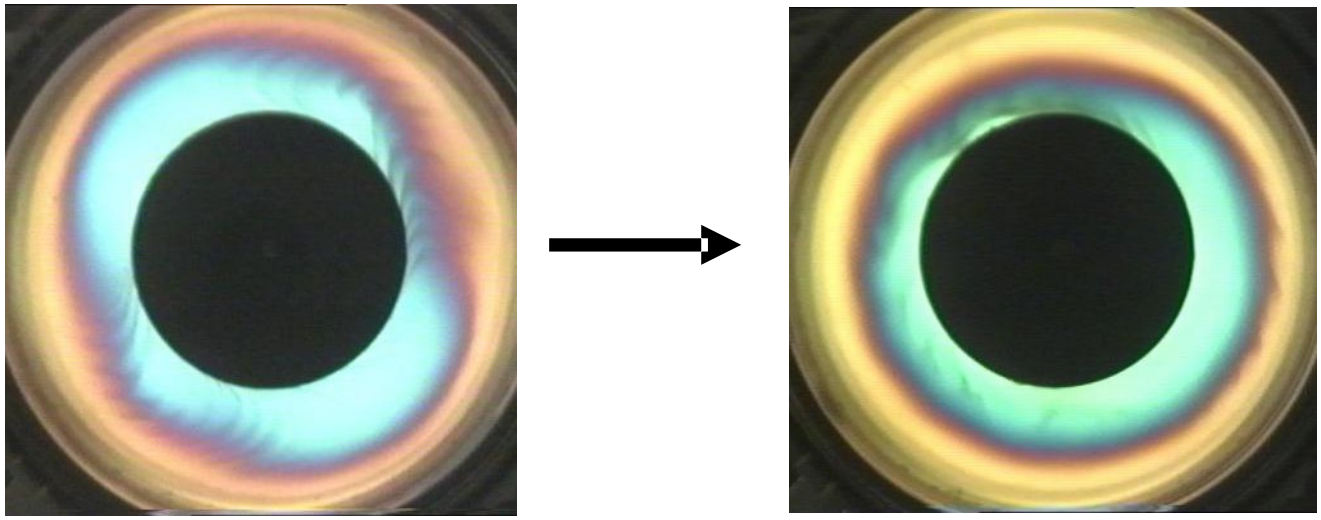
Wunsch & Ferrari (2004)

# 6. Application to atmospheric regimes

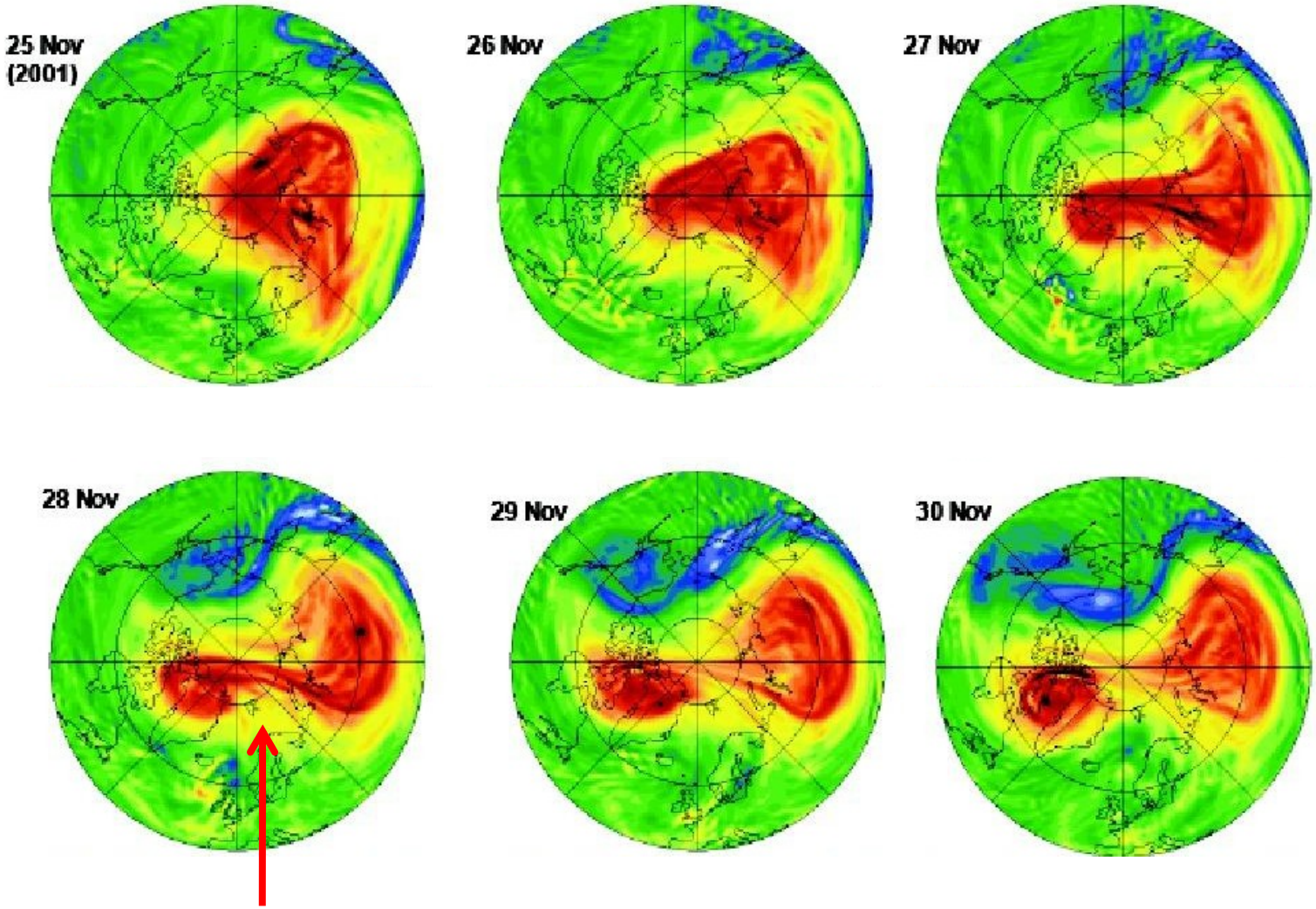
without gravity waves



with gravity waves (‘noise’-induced transition)

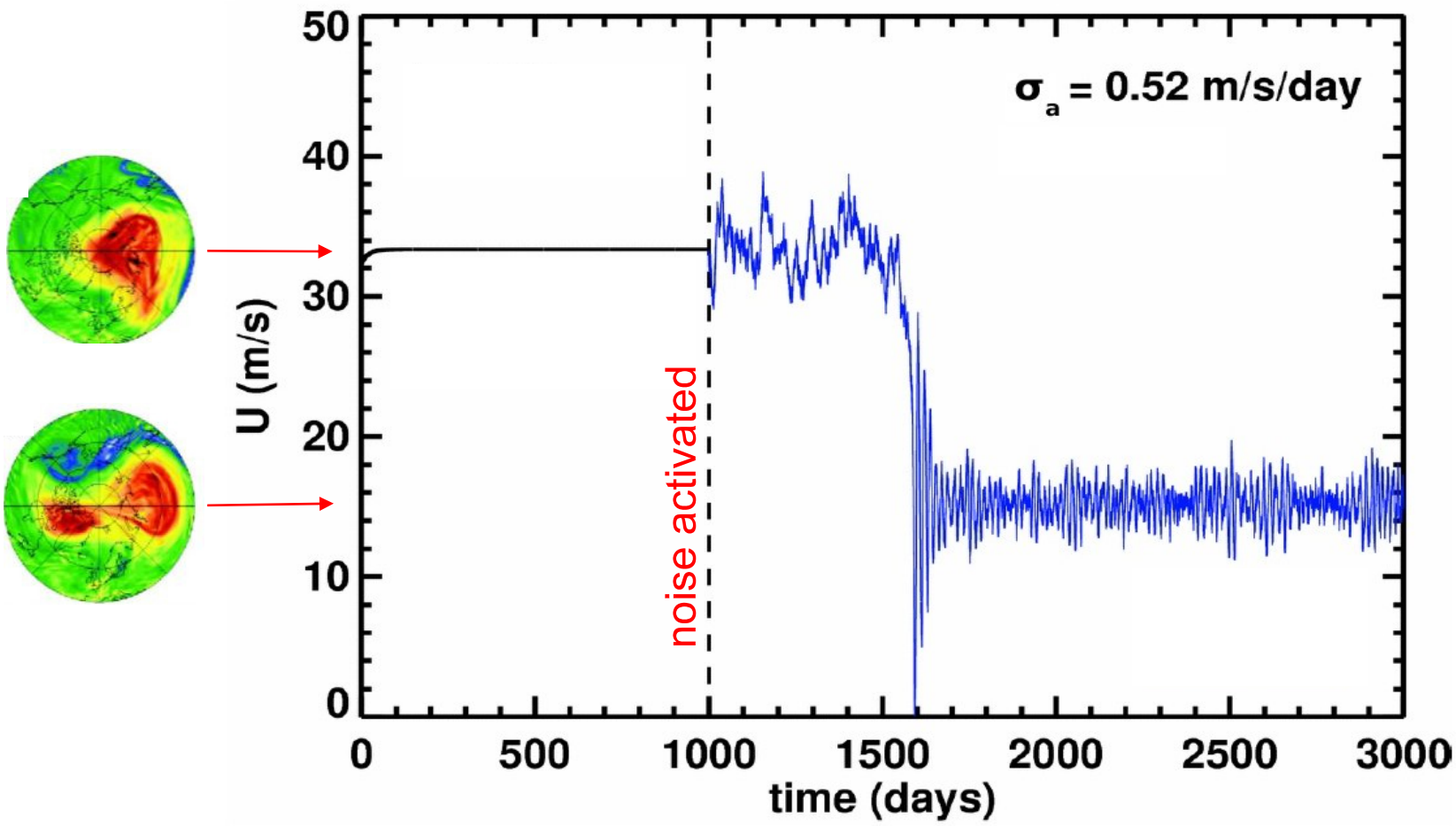


# 7. Application to atmospheric regimes




polar vortex split in satellite observations

# 8. Application to atmospheric regimes




→ new noise-induced interpretation of polar vortex splits!

Birner & Williams (JAS; 2008)

# References

Visit www.met.rdg.ac.uk/~williams
for downloadable published papers