Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

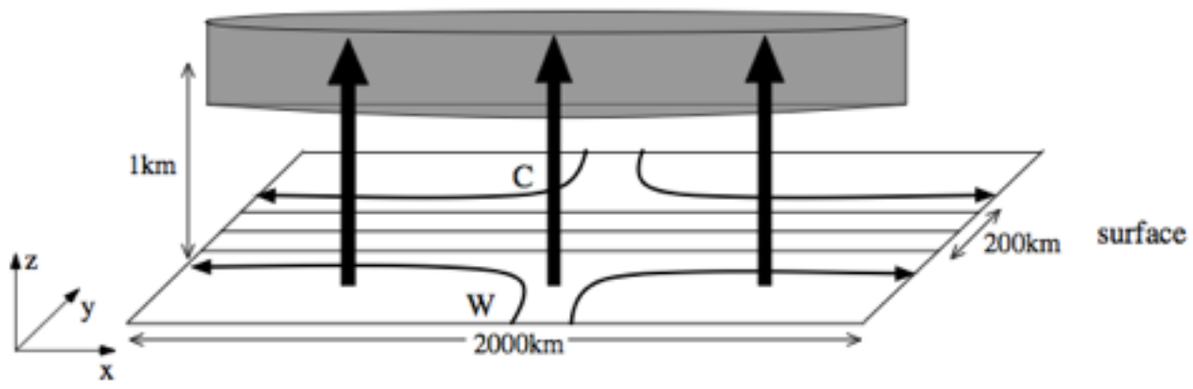
Bjerknes Centre
for Climate Research

Frontal-wave cyclogenesis in the North Atlantic - A climatological characterization

Sebastian Schemm and Michael Sprenger

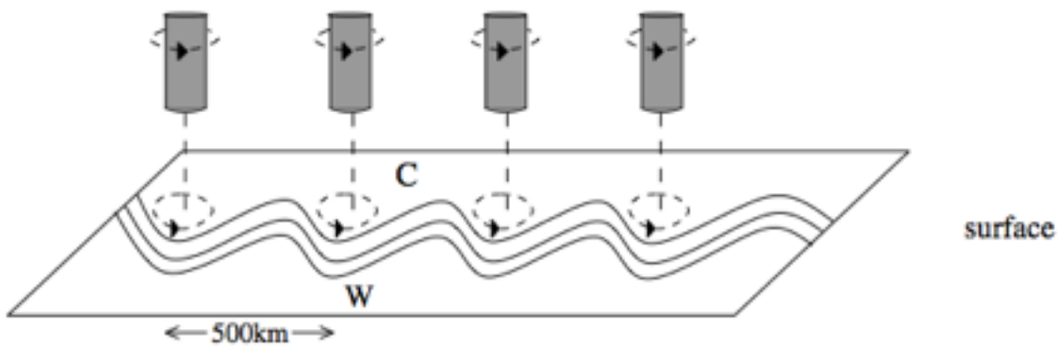
frontal-wave growth mechanism: concept

(a)



Deformation field → Vertical motion → Latent heat release → Positive PV anomaly strip

(b)



Deformation field reduces → PV strip breaks up → Cyclonic circulation → Frontal waves

Figure 1. A conceptual model for barotropic frontal-wave development. (a) First stage of frontal-wave development—formation of PV strip, (b) second stage of frontal-wave development—break-up of PV strip. Contours are isotherms, shading is positive PV anomaly. Thin arrows represent the deformation strain flow, thick arrows represent vertical ascent and dashed arrows represent horizontal circulations.

Two step process:

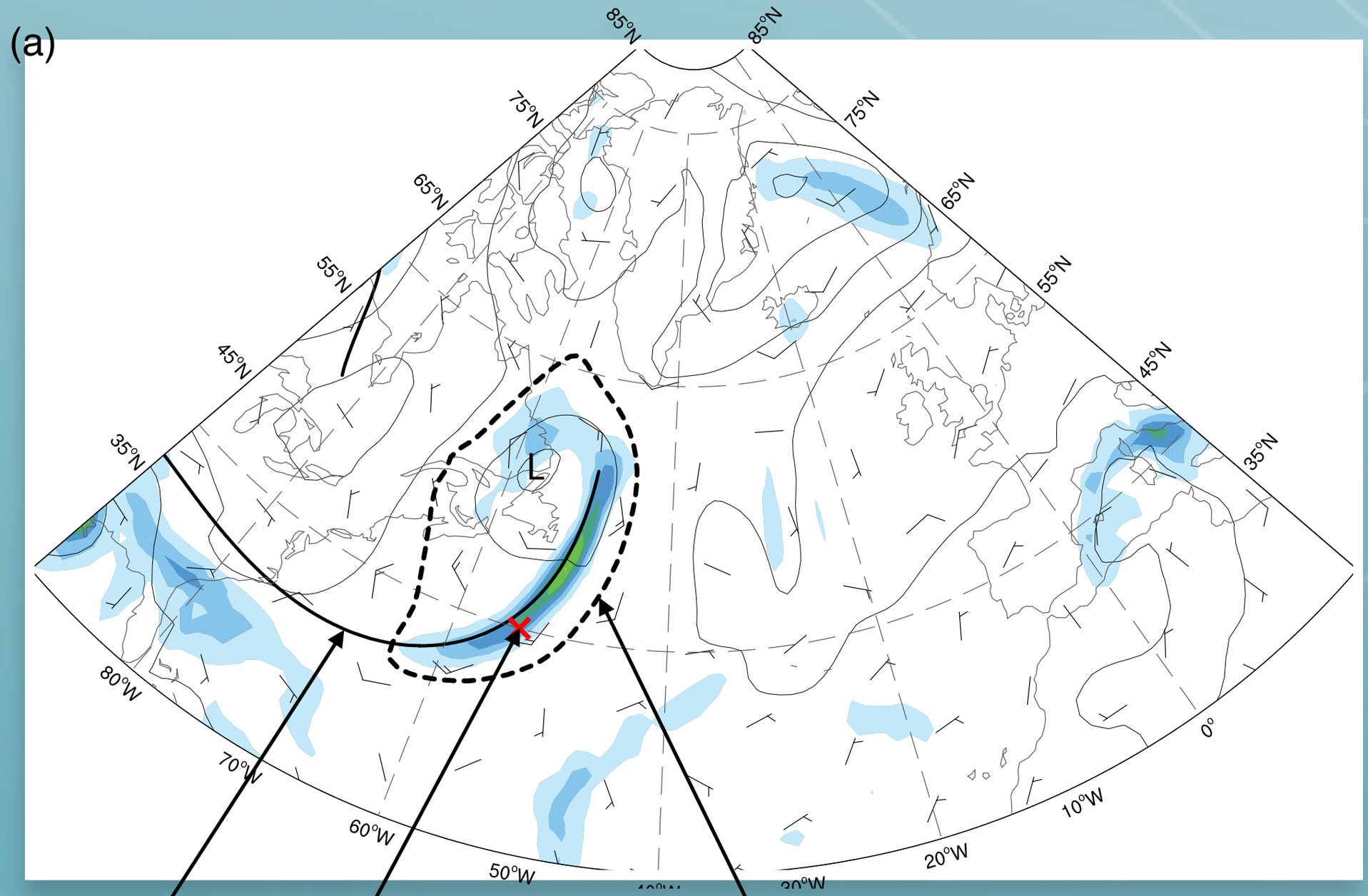
diabatic formation of PV band
strong deformation supports formation

Later: if deformation is too strong frontal waves are „flattened“.

break-up of PV band
edge-wave growth
interaction with upper-level PV anomaly
translation into baroclinic system

Dacre & Gray (2006)

frontal-wave cyclogenesis: identification



trailing front

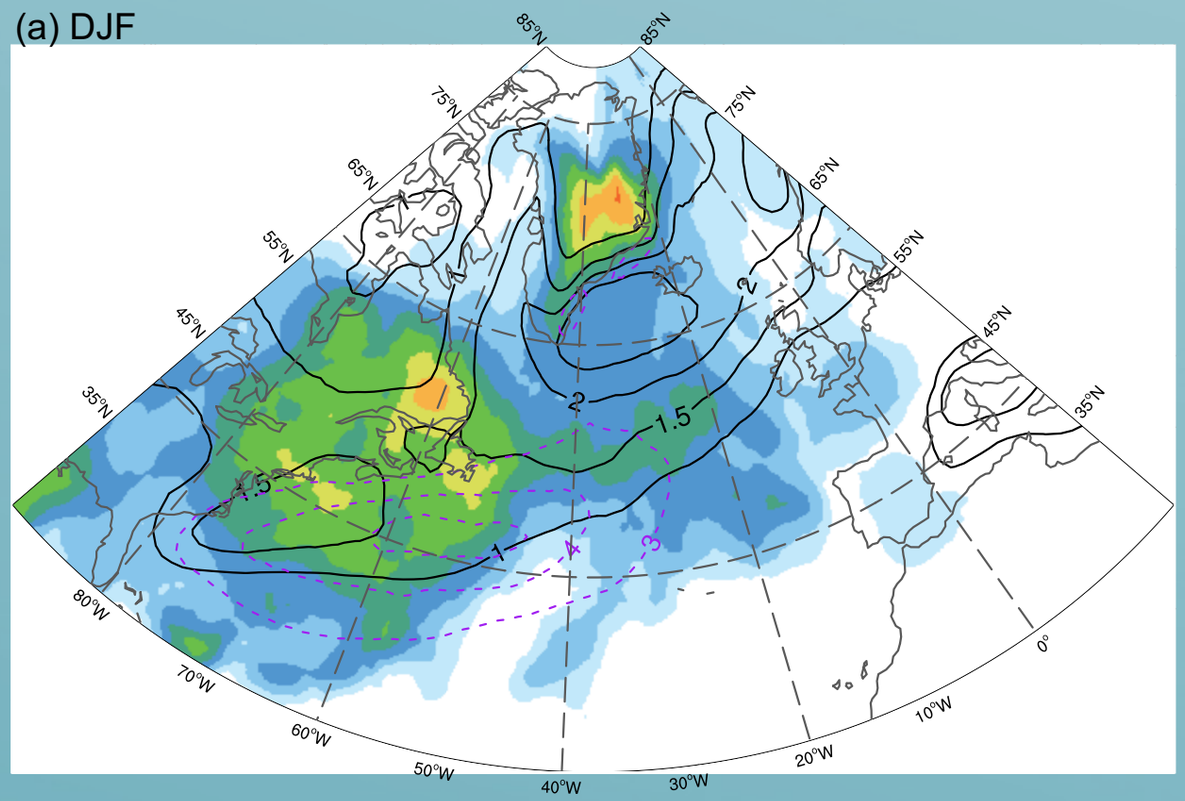
genesis

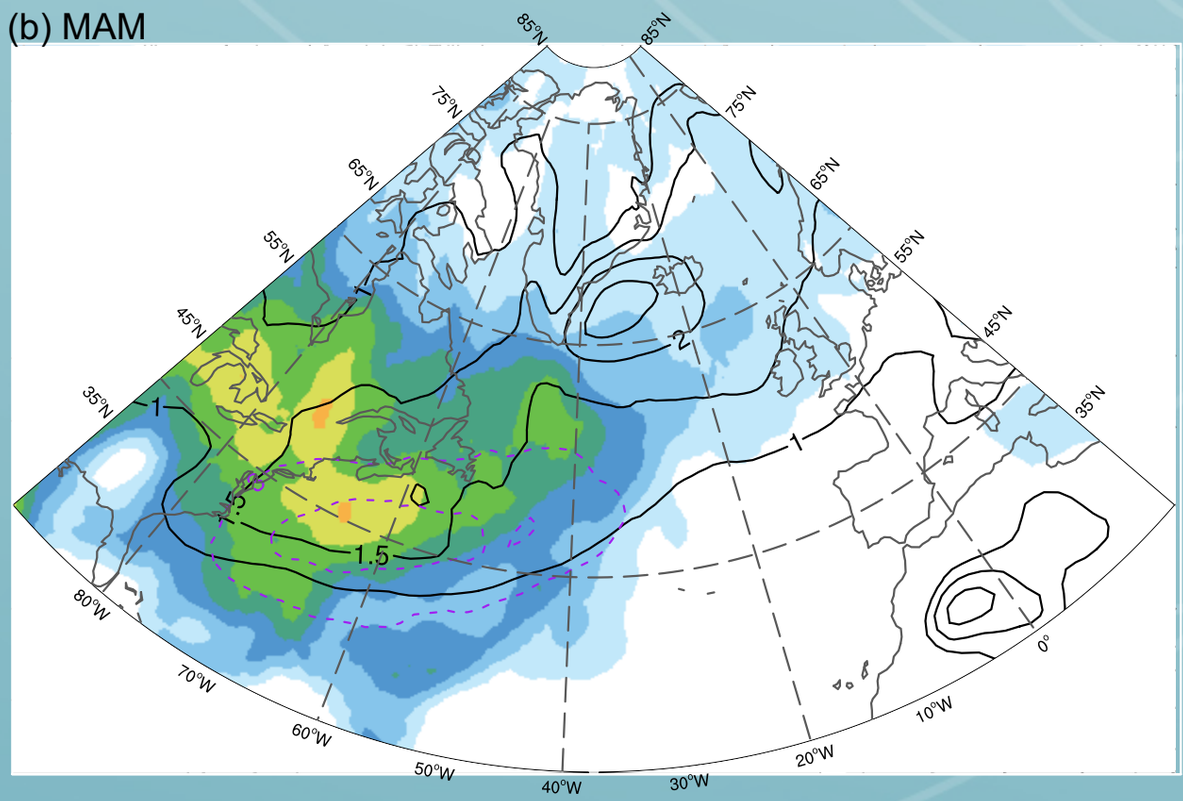
outermost SLP contour of parent cyclone

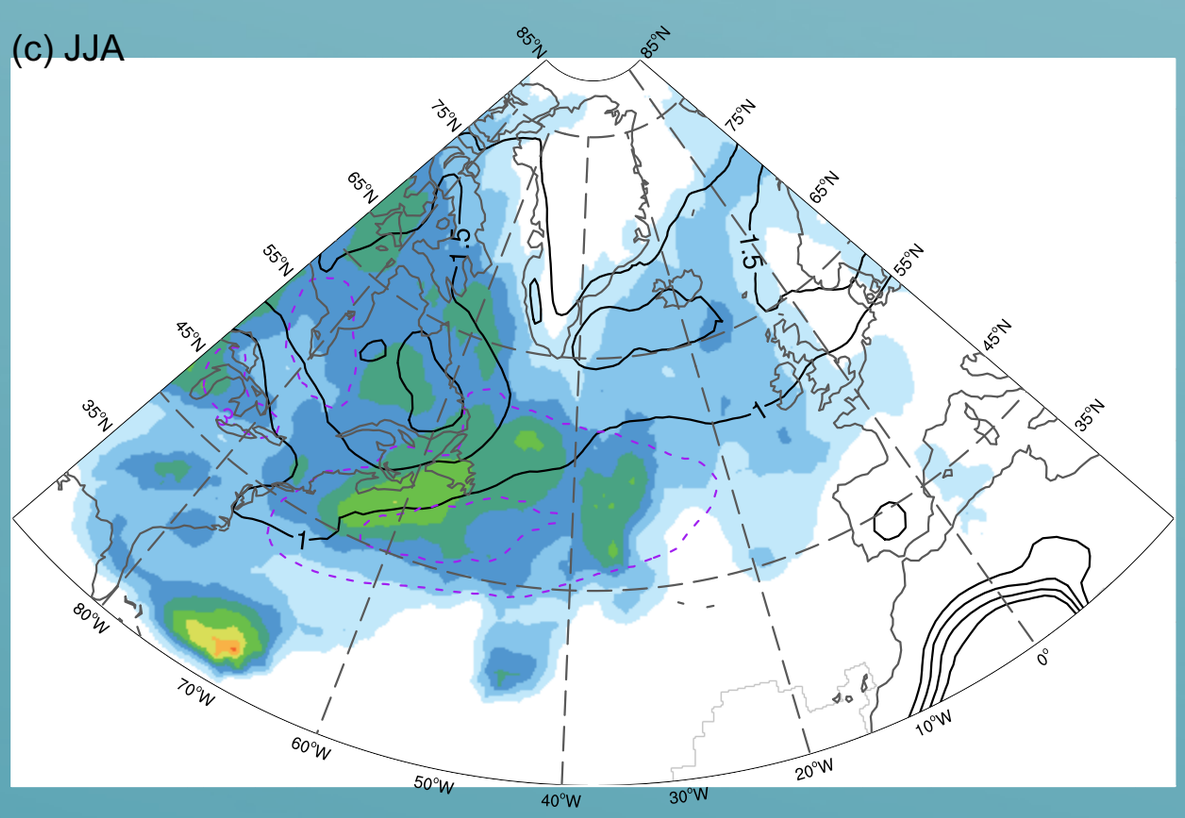
Cyclogenesis on a trailing fronts is frontal-wave cyclogenesis

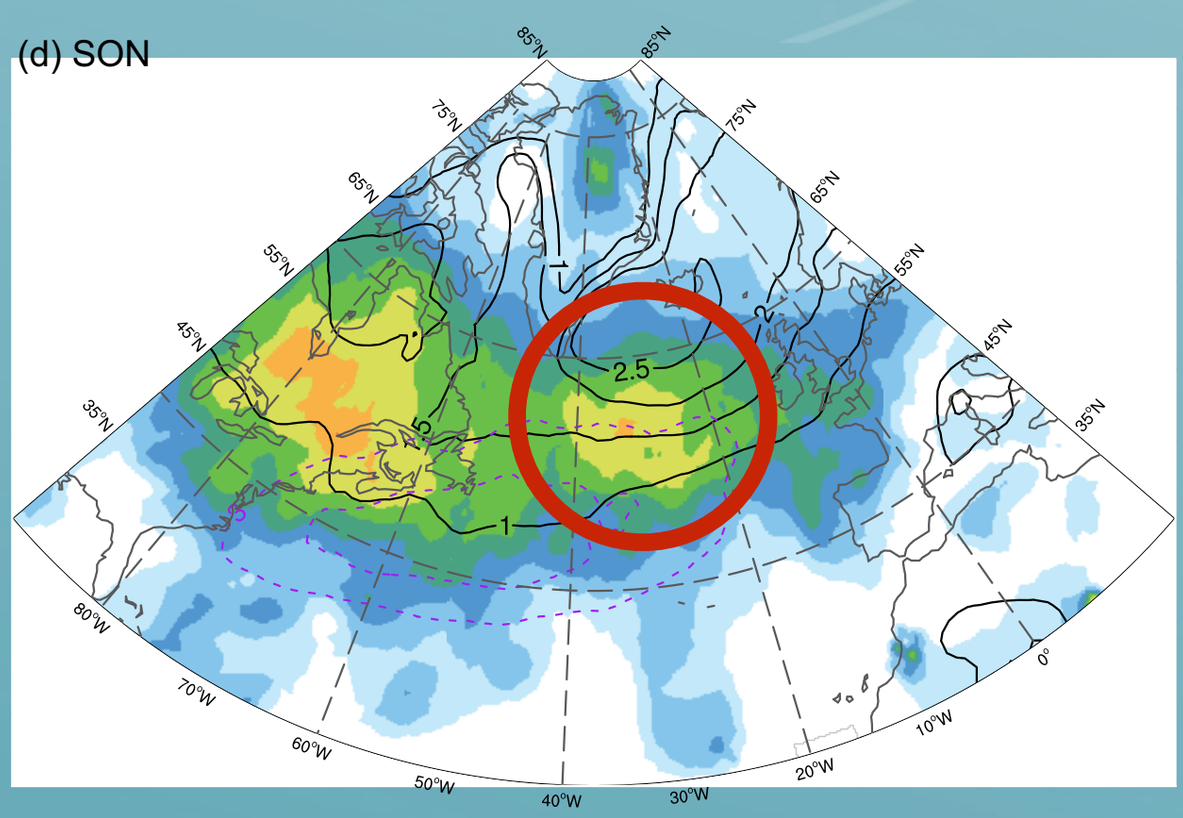
Schemm & Sprenger (2015)

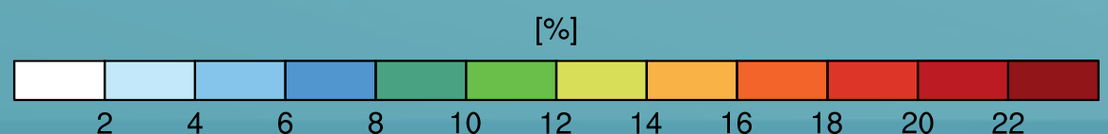
frontal-wave cyclogenesis: climatology











Schemm & Sprenger (2015)

frontal-wave cyclogenesis: the role of along-frontal stretching

$$\frac{\partial[\ln(\mathscr{A})]}{\partial T'} = \frac{\partial \gamma}{\partial T'} - 2\alpha - \frac{d[\ln(\Delta\bar{\zeta}_n)]}{dT'}$$

$$= (\Delta\bar{\zeta}_n/2)e^{-2\mu}\sin(\Delta\chi) - \frac{2\alpha}{f}(\bar{\zeta}_2 + \bar{\zeta}_4). \quad (5.6)$$

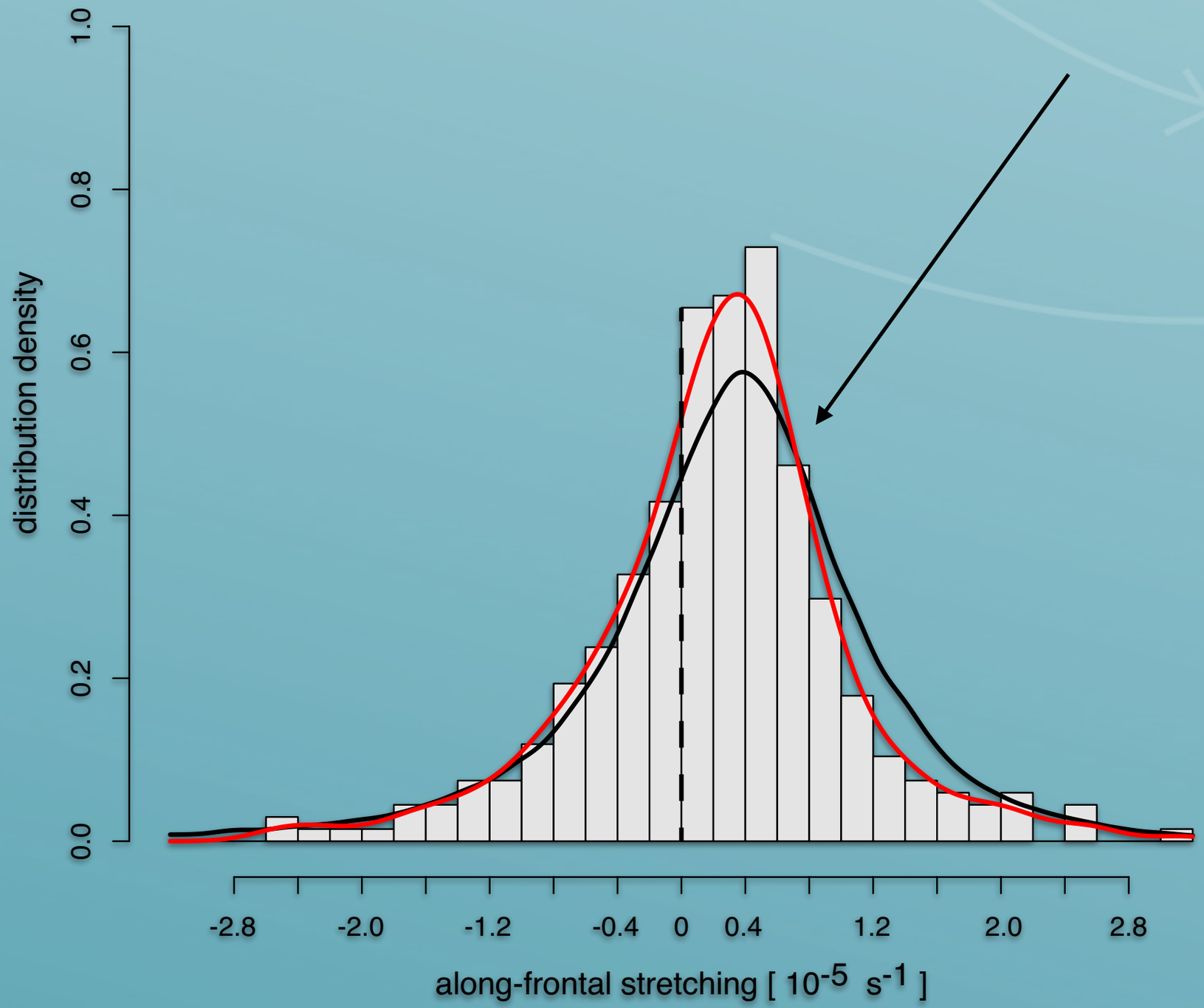
The last term in this equation is negative definite and is proportional to (α/f). Since $(\bar{\zeta}_2 + \bar{\zeta}_4)$ always has the same order of magnitude as $\Delta\bar{\zeta}_n/2$ we have the rather general result that:

There is *always a strain rate* that can completely suppress *wave steepening*. This is true even when the

Bishop & Thorpe (1994)b

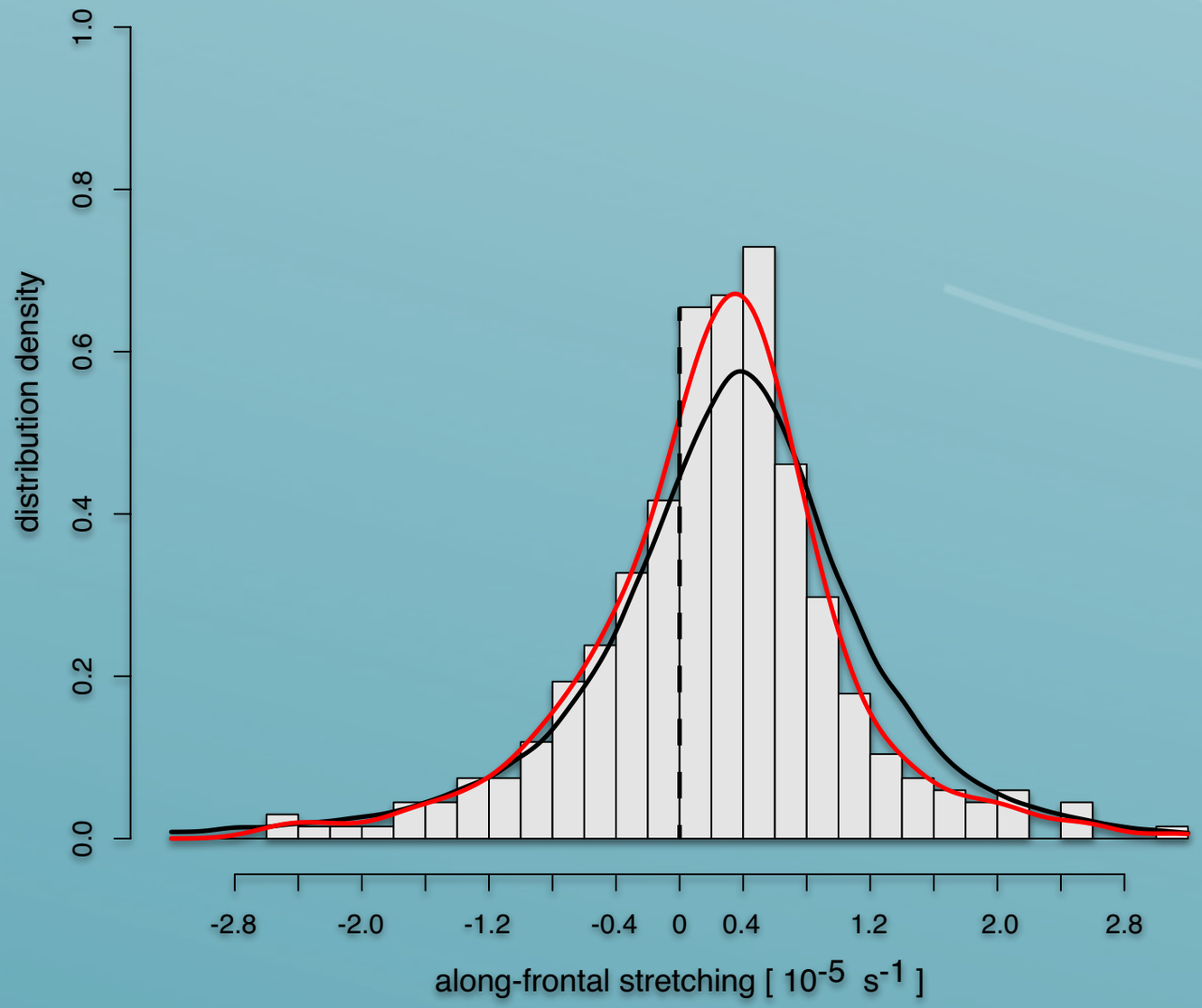
(…) that frontal-wave growth is very unlikely in persistent strain rates greater than 0.6×10^{-5} s^{-1}

frontal-wave cyclogenesis: the role of along-frontal stretching



Schemm & Sprenger (2015)

frontal-wave cyclogenesis: the role of along-frontal stretching



- Above this threshold frontal-wave cyclogenesis is strongly suppressed.
- Valuable information for forecasting.

Schemm & Sprenger (2015)

frontal-wave cyclogenesis: climatology of along-frontal stretching

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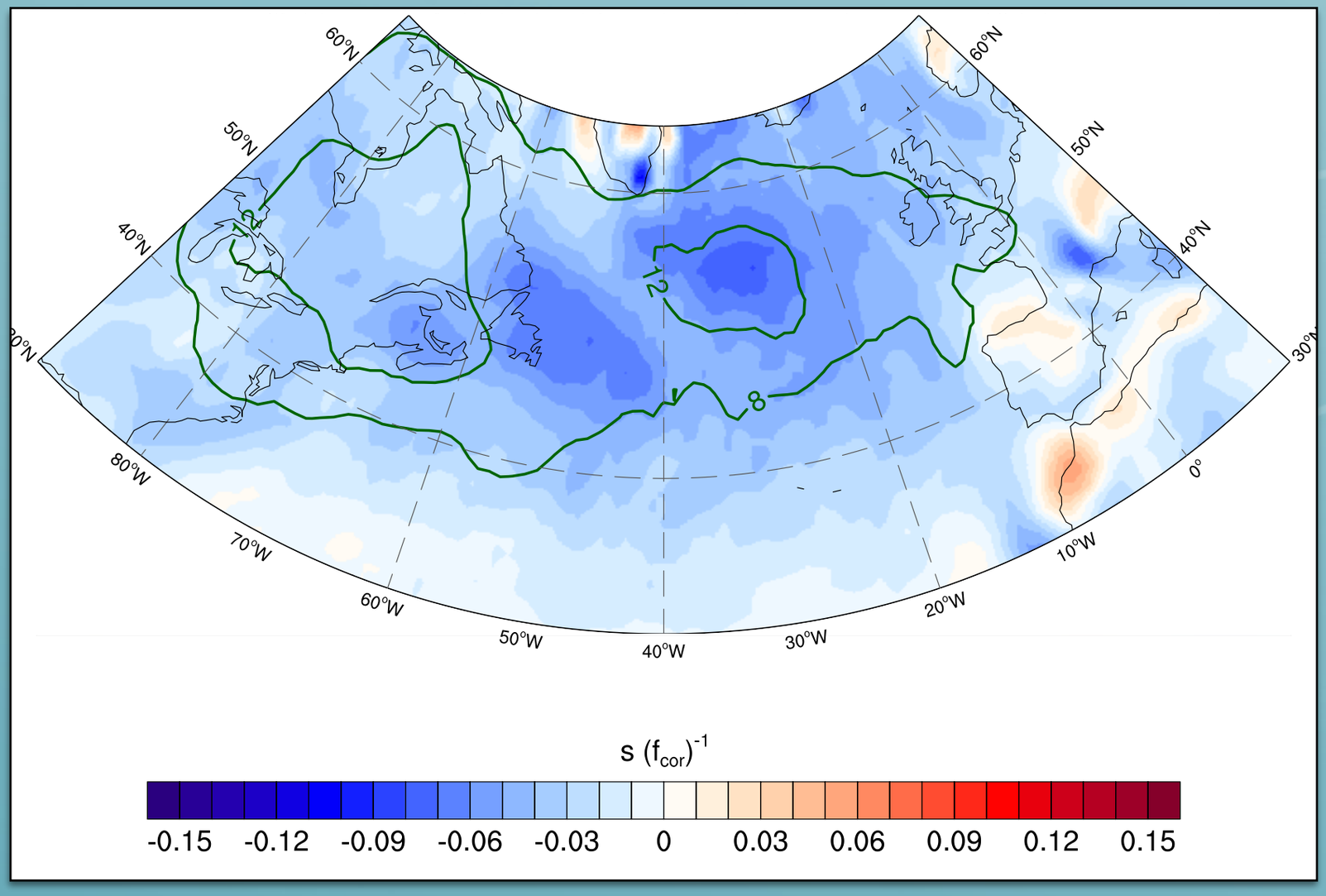
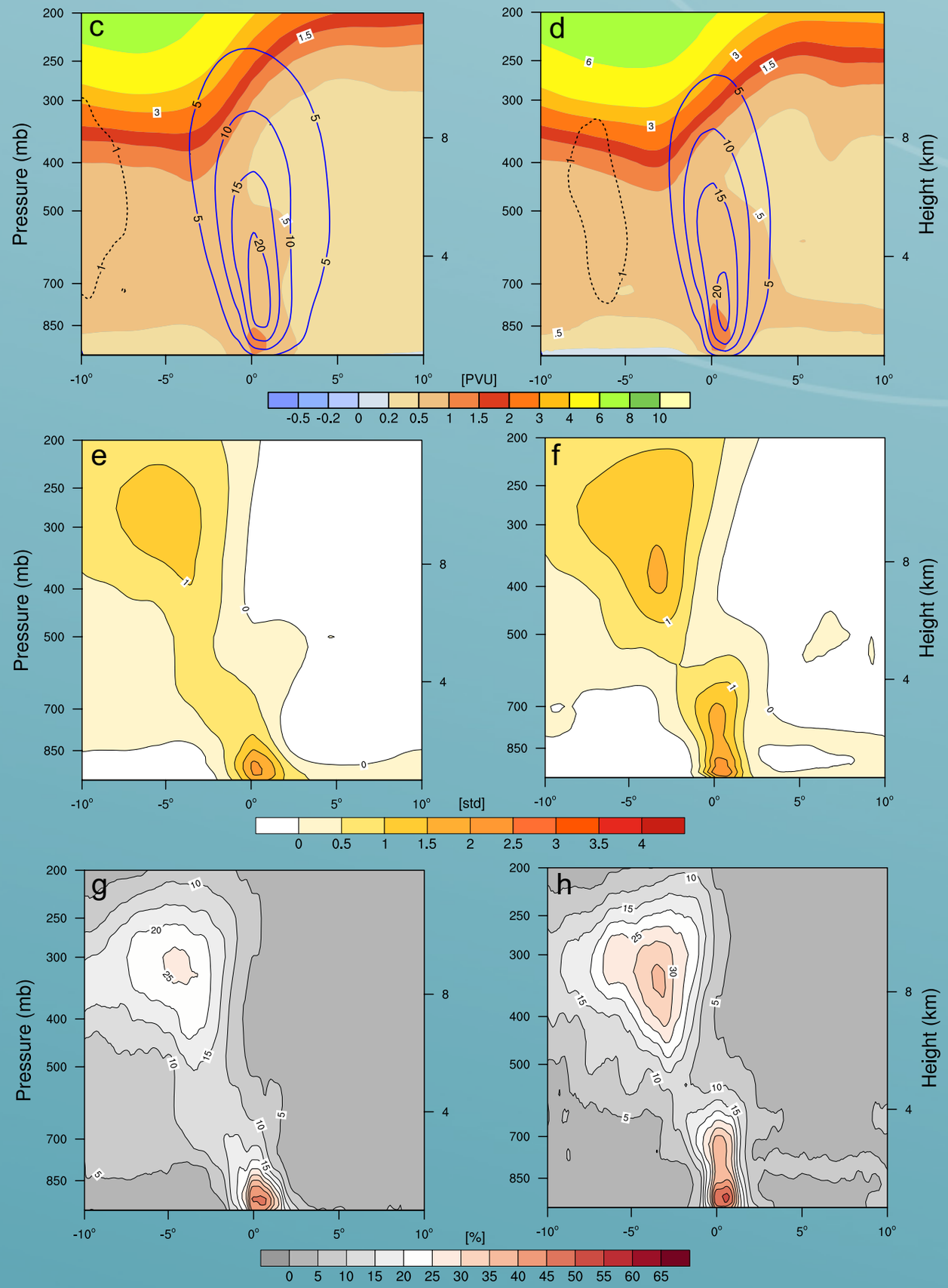


Schemm & Sprenger (2015)

frontal-wave cyclogenesis: vertical cross-sections



Schemm & Sprenger (2015)