Explicit convection global modelling: how does it compare with a nested high resolution model hierarchy?

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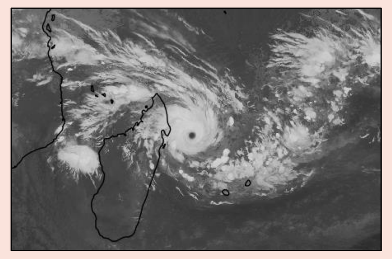
It is possible to run high resolution explicit convection global models

But should we do this in our operational forecasts?

- For the first time, we have run global convection-permitting Met Office Unified Model (MetUM) simulations at <10km resolution.
- To assess the costs/benefits, we compare their performance to our high-resolution "model hierarchy" (Figure 1):
  - Global models (with parameterised convection schemes or with explicit convection).
  - Cyclic Tropical Channel.
  - Continental-scale limited area models (LAMs).
- This poster explores initial results focussing on an active MJO event in the South East Asia region.



Tropical Cyclone Ava

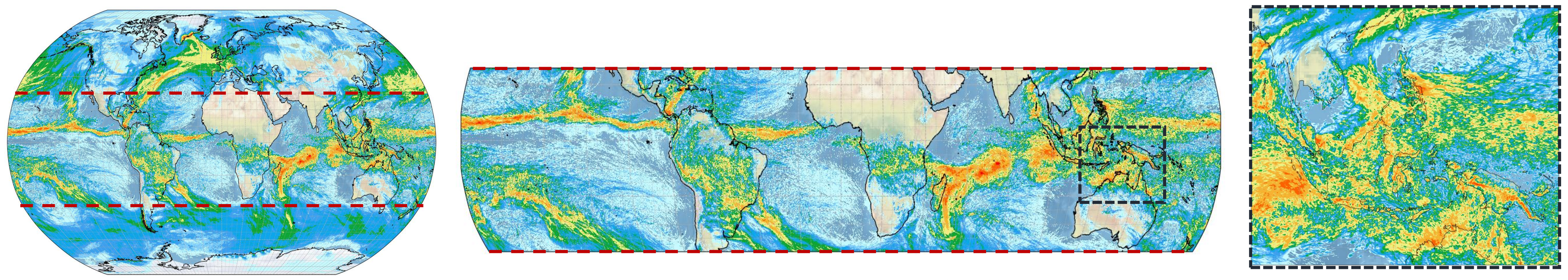
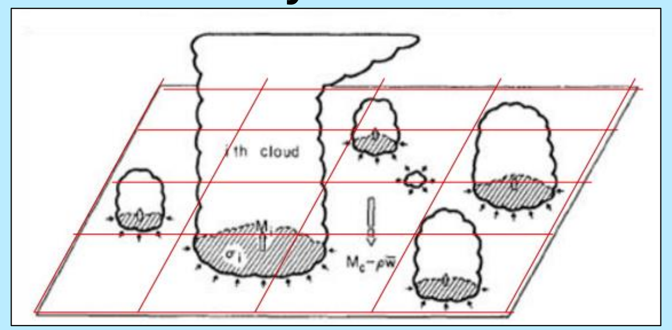


Figure 1. Extract of Met Office K-Scale modelling hierarchy. The LAM and the Cyclic Tropical Channel are nested within a coarser global driving model.

Modelling hierarchy

Grey Zone



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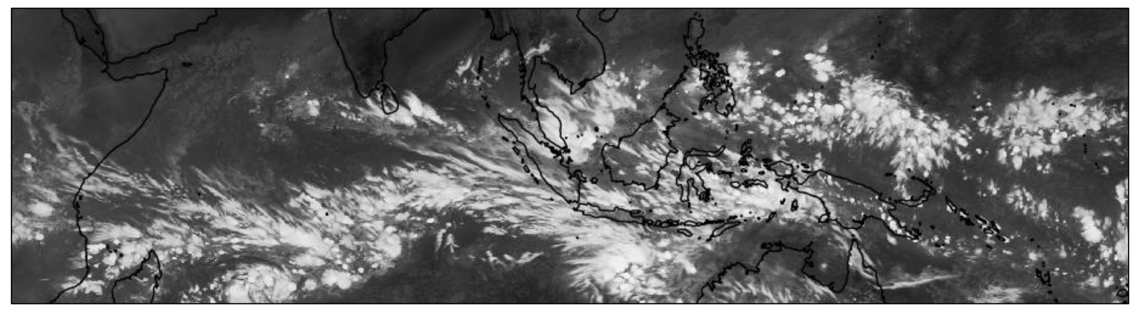
The resolution of our models means that convection is only partly resolved *(Tomassini et al., 2022)*.

Domain	Resolution	Convection	Driving model	Computational cost (relative)
Global	10km	Parameterised	N/A	1
Global	5km	Parameterised	N/A	11
Global	10km	Explicit	N/A	1.4
Global	5km	Explicit	N/A	14
Cyclic Tropical Channel	5km	Explicit	Global explicit convection 10km	1.9
South East Asia LAM	2.2km	Explicit	Global explicit convection 10km	4.8

- A shift to higher resolution implies improved representation of small scale processes (e.g. *Prein et al., 2015*) hence we use models with different resolutions for specific applications.
- Testing both explicit and parameterised global models allows us to evaluate the sensitivity of MetUM simulations to the treatment of convection (*Clark et al., 2016*).
- The Cyclic Tropical Channel has no east/west boundaries. It allows us to capture, in high resolution, tropical weather systems as they evolve and propagate across land and ocean.
- Running a LAM allows us to understand the sensitivity to increased horizontal resolution and lateral boundary conditions.



The MJO over the Indian Ocean and Maritime Continent, 14th January 2018

Model performance against the active January 2018 MJO

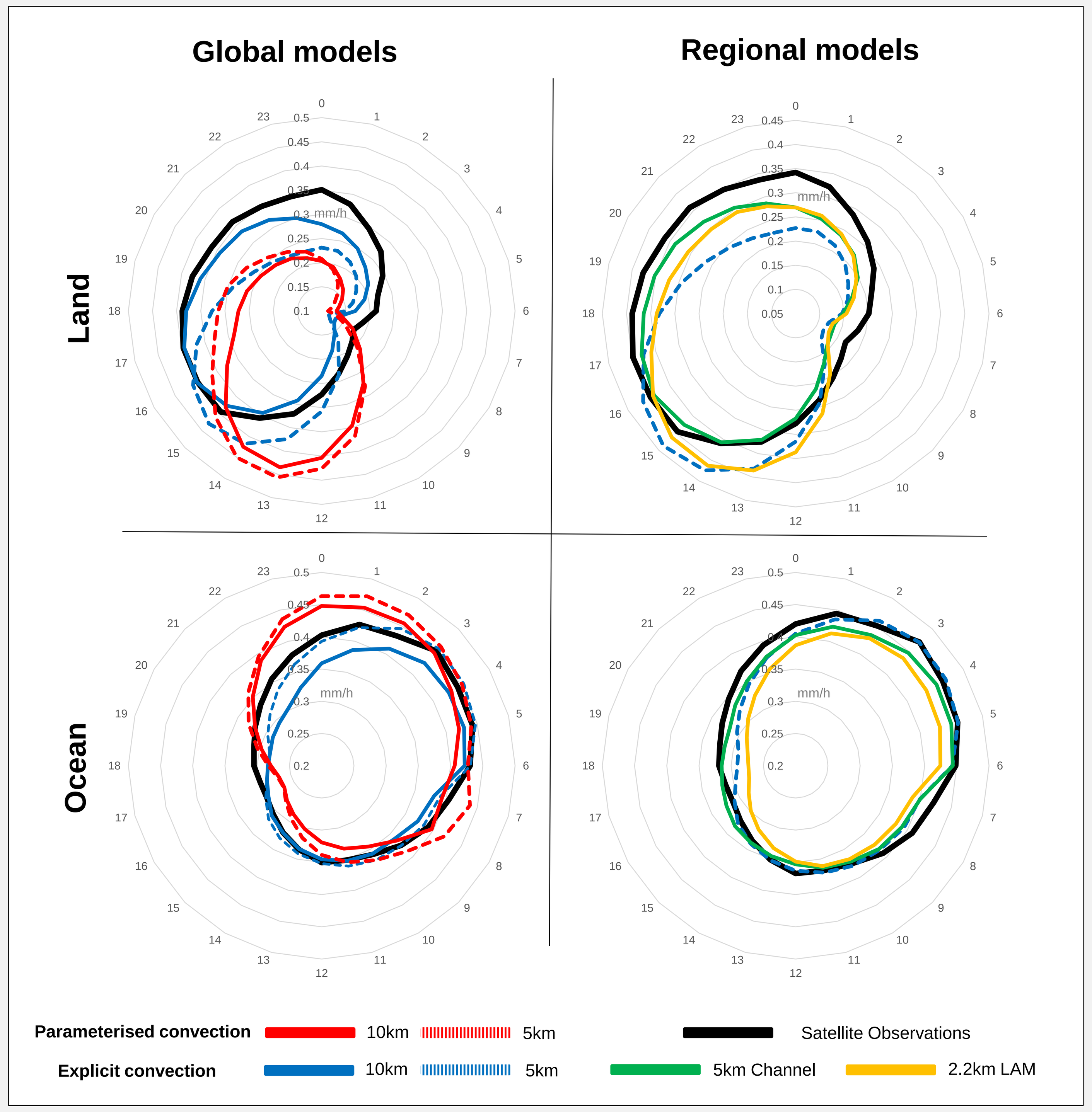


Figure 2. Diurnal cycles of rainfall by hour of day, all times are in local time (UTC +7). Region: -18 to 20°N and 90 to 130°E.

- Global parametrised convection models incorrectly predict the daytime maximum diurnal cycle amplitude to be 3 hours earlier than observed.
- Parameterised and explicit convection global models have smaller errors in the timing and the amplitude of the diurnal cycle over the ocean – most likely due to the absence of land based forcings (*Yang and Slingo., 2001*).
- Comparing the Cyclic Tropical Channel (~5km resolution) to the South East Asia LAM (2.2km resolution) shows there is little sensitivity of the diurnal cycle to horizontal resolution or extending the size of the tropical domain.
- The explicit convection 5km global model has relatively large errors in the timing and amplitude of the diurnal cycle over land – this model configuration is still in development and further refinements are needed.

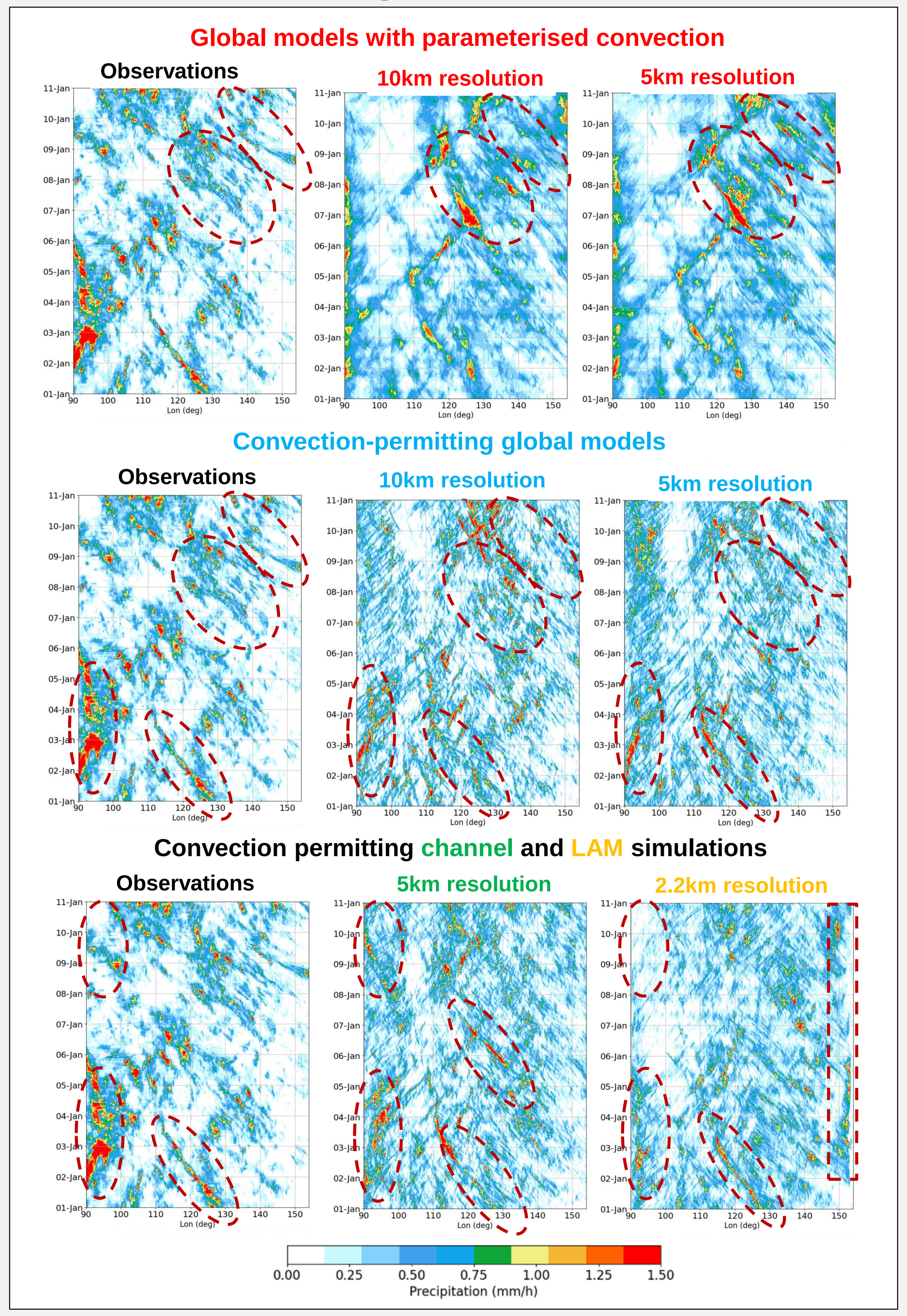
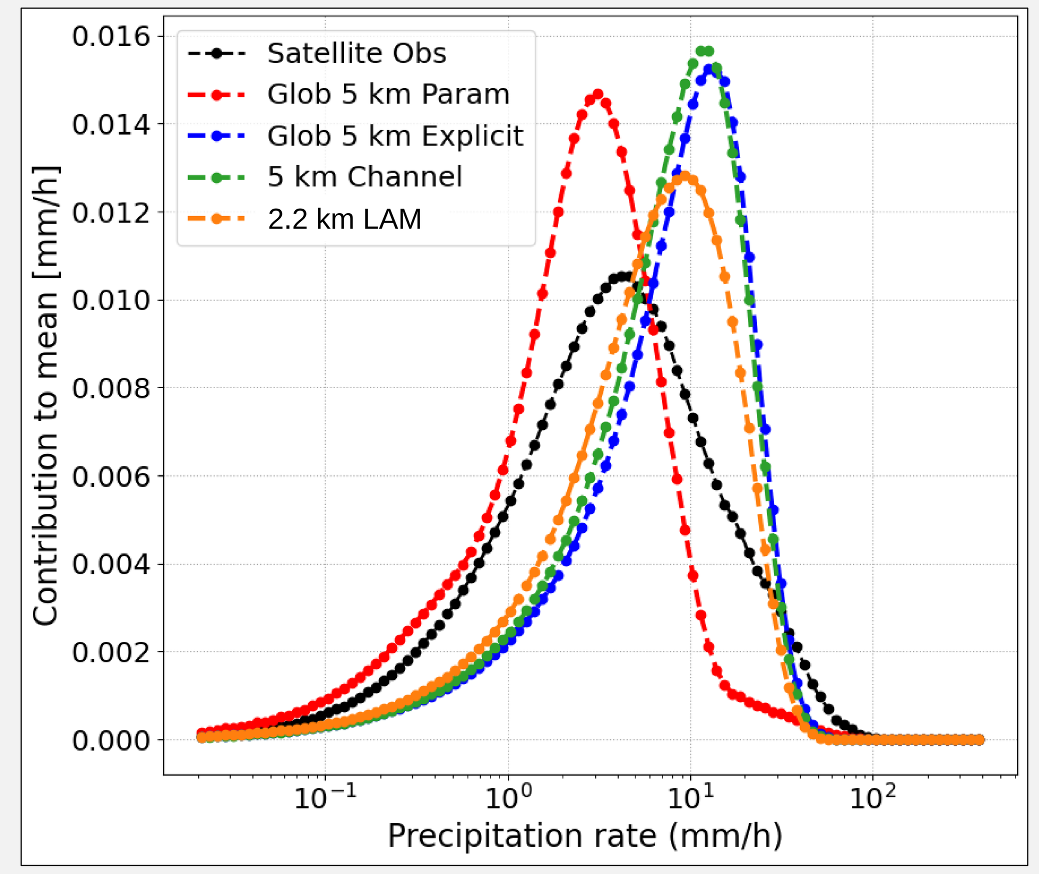


Figure 3. Longitude-time precipitation Hovmöllers averaged across 15°S to 15°N and 91°E to 153°E. Analysis from T+48 to allow model spin-up.

- On the 7th of January at 125°E, global parameterised convection models heavily overestimate precipitation.
- The tropical depression that propagates westwards from the 1st of January at 130°E is best represented by the LAM and other convection-permitting models, albeit still underestimated.
- The active deep convection at the western boundary of the domain is underestimated in intensity and extent in all models, though better represented by explicit convection models.
- MJO amplitude and propagation being much weaker than observed is one known deficiency of parameterized convection simulations of the Met UM (*Holloway et al., 2013*).



- The global parameterised convection configuration overestimates the occurrence of lighter rain rates.
- Explicit convection global and regional simulations overestimate frequency of moderate and heavy rainfall (> 10 mm/hr) but underestimate contribution from light rainfall (< 2 mm/hr).

Conclusions

- **Initial results show a greater sensitivity to model physics compared to model resolution.**
- **Whilst convection-permitting models show an improvement, they still display well-known deficiencies of the Met UM (underestimation of intense rainfall and accurate representation of MJO propagation).**
- **Further model development is required to fully understand the true benefits of global simulations at km-scales with explicit convection.**

Future work

- We plan to run longer duration simulations (e.g. DYAMOND summer and winter *Stevens et al., 2019*) to build a better understanding of how sensitive tropical wave propagation is to both horizontal resolution and whether convection is parameterised or explicit.
- Exploiting our global and regional model hierarchy to try to understand if, where and why forecast skill is improved through explicitly representing convection across the tropics.

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Abstract