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Dissipative models generalizing the 2D Navier-Stokes and the surface quasi-geostrophic equations

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This paper is devoted to the global (in time) regularity problem for a family of active scalar equations with fractional dissipation. Each component of the velocity field u is determined by the active scalar θ through $\mathcal{R} \Lambda^{-1} P(\Lambda) \theta$ where $\mathcal{R}$ denotes a Riesz transform, $\Lambda=(-\Delta)^{1/2}$ and $P(\Lambda)$ represents a family of Fourier multiplier operators. The 2D Navier-Stokes vorticity equations correspond to the special case $P(\Lambda)=I$ while the surface quasi-geostrophic (SQG) equation to $P(\Lambda) =\Lambda$. We obtain the global regularity for a class of equations for which $P(\Lambda)$ and the fractional power of the dissipative Laplacian are required to satisfy an explicit condition. In particular, the active scalar equations with any fractional dissipation and with $P(\Lambda)= (\log(I-\Delta))^\gamma$ for any $\gamma>0$ are globally regular.

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